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LABORATORY VERIFICATION TEST AGREEMENT NO. CJ-002

J. Keith Carswell

National Environmental Research Center

Prepared for:

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July 1974

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FINAL REPORT

LABORATORY VERIFICATION TEST
AGREEMENT NO. CJ-002

PARTIES TO THE AGREEMENT

The Foundation:	The Innovator:	The Testing Agent:
National Science Foundation Washington, D. C.	Alron Industries, Inc. Rochester, New York	USEPA National Environmental Research Center Water Supply Research Laboratory Cincinnati, Ohio

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Report prepared by:

J. Keith Carswell
Project Officer for the Testing Agent

July 1974

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16. Abstract: This final report presents a descriptive summary, including operational data, of a project undertaken to investigate an innovative water purification system developed by Aqua Industries of Yonkers, New York. The tests were to determine effectiveness in removing a variety of inorganic and organic contaminants. This project was funded by NSF in order to obtain verification of selected product performance parameters by an independent, scientifically recognized organization, as a means of influencing the future commercial development and market for potential users of the tested system.

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TABLE OF CONTENTS

	Page
SUMMARY	iv
INTRODUCTION	1
ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER	2
1. Miscellaneous Operating Parameters	4
2. Iron Removal	9
3. Total Sulfide Removal	11
4. Manganese Removal	11
5. Removal of Organic Compounds	14
a. Dieldrin	14
b. Styrene, Ethylbenzene and 1,2-Dichloroethane	16
c. Linear Alkyl Sulfonate	20
6. Changes in General Organic Parameters	20
7. Removals of Bacteria and Virus	26
8. Reduction of Threshold Odor Number	28
9. Removal of Apparent Color Caused by Iron and Manganese	29
10. Changes in Trace Elements and other Chemical Parameters	31
11. Operating Problems	34
ALRON MODEL 45 PORTABLE WATER PURIFIER	35
1. Ozone Output	36
2. Dissolved Ozone	39
3. Ozone in Air near Operating Portable Units	40
4. Iron Removal	41
5. Manganese Removal	41
6. Organics Removal	42
7. Removal of Apparent Color Caused by Iron	43
8. Portable Unit Failures	44

	Page
BIBLIOGRAPHY	45
ACKNOWLEDGMENTS	46
APPENDICES	
Appendix A - Laboratory Verification Testing Agreement	47
Appendix B - Test Protocol for the Laboratory Verification Testing Agreement	55
Appendix C - Specifications: Alron Model WP Water Purifier with Model AF Automatic Backwash Filter	65
Appendix D - Test Log: Alron Model WP Water Purifier with Model AF Automatic Backwash Filter	67
Appendix E - Specifications: Alron Model 45 Portable Water Purifier	72
Appendix F - Test Log: Alron Model 45 Portable Water Purifier	74
LIST OF FIGURES	
Alron Model WP Water Purifier with Model AF Automatic Backwash Filter	
Figure No. 1: Experimental Set-up	3
Figure No. 2: Iron Removal	10
Figure No. 3: Total Sulfide Removal	12
Figure No. 4: Manganese Removal	13
Figure No. 5: Dieldrin Removal	15
Figure No. 6: Styrene Removal	17
Figure No. 7: Ethylbenzene Removal	18
Figure No. 8: 1,2 Dichloroethane Removal	19
Figure No. 9: Linear Alkyl Sulfonate Removal	21
LIST OF TABLES	
Alron Model WP Water Purifier with Model AF Automatic Backwash Filter	
Table No. 1: Ozone-Air Mixture Flowrate	5
Table No. 2: Ozone Concentration in Ozone-Air Mixture	7
Table No. 3: Effluent Dissolved Ozone Concentrations	7
Table No. 4: Air temperature, Relative Humidity, and Ozone Concentration in Air near Operating Unit	8

Table No. 5:	Water Temperature Rise and Pressure Drop	9
Table No. 6:	Changes in General Organic Parameters of Cincinnati Tap Water	23
Table No. 7:	Changes in General Organic Parameters of Cincinnati Tap Water Spiked with Specific Organic Compounds	24
Table No. 8:	Removal of Bacteria and Virus	27
Table No. 9:	Reduction of Threshold Odor Number	30
Table No. 10:	Apparent Color Removal	31
Table No. 11:	Changes in Trace Elements and other Chemical Parameters	32

Alron Model 45 Portable Water Purifier

Table No. 12:	Ozone Output Concentration and Ozone-Air Flowrate Units Received 10/1/73	36
Table No. 13:	Ozone Output Concentration and Ozone-Air Flowrate - Units Received 10/18/73	37
Table No. 14:	Ozone Output Concentration and Ozone-Air Flowrate - Units Received 3/7/73	38
Table No. 15:	Ozone Output Concentration and Ozone-Air Flowrate - Units Received 3/7/74 - 2nd test	38
Table No. 16:	Dissolved Ozone Production - Units Received 3/7/74	39
Table No. 17:	Ozone Concentrations in Air Near Operating Units Received 3/7/73	40
Table No. 18:	Iron Removal	41
Table No. 19:	Manganese Removal	41
Table No. 20:	Organics Removal	42
Table No. 21:	Organics Removal - 2nd Test	43
Table No. 22:	Apparent Color Removal	43
Table No. 23:	Total Operating Time Before Failure	44

SUMMARY

1. Verification testing, as described herein, does not imply "Approval" or "Endorsement" by the Testing Agent of the devices tested or of the concept of allowing untrained persons to treat their own drinking water supplies for the removal of chemical or microbiological agents that may be hazardous to their health.

Alron Model WP Water Purifier with Model AF Automatic Backwash Filter (now marketed as Model No. WP-360)

1. The following table summarizes the test results obtained for specific inorganic and organic contaminants. Most of the tests were run at the system's rated capacity of 6 gpm. The remainder were run at either 2 or 4 gpm.

Chemical Contaminant	Concentration Range Tested	Removal Efficiency Range	Remarks
Iron	0.1 - 5.9 mg/l	36 - 76%	Some improvement at conc. < 1.0 mg/l
Total Sulfide	6.5 - 49 mg/l (titration method)	0 - 72%	Definite improvement at ≈ conc. 10 mg/l
Manganese	0.4 - 4.2 mg/l	14 - 70%	Some improvement at conc. < 1.0 mg/l
Dieldrin	310 - 1100 ng/l	19 - 26%*	Removal efficiency essentially constant
Styrene	0.3 - 1.15 mg/l	100%*	Removal efficiency constant
Ethylbenzene	0.5 - 2.6 mg/l	38 - 85%*	Most removal in the range 40 - 60%
1,2 Dichloroethane	0.2 - 3.8 mg/l	4 - 33%*	Most removals <10%
Linear Alkyl Sulfonate	0.21 - 0.81 mg/l	0 - 30%	Slight improvement at higher concentrations

*Indicates removal of original compound. Oxidation products may remain in water that was treated.

2. The system will remove some (<35%) Carbon-Chloroform Extract (CCE-m) But has little effect on the reduction of Total Organic Carbon (TOC).

3. When spiked into dechlorinated Cincinnati tap water, the system effectively removed a variety of bacteria commonly found in the raw water sources for drinking water.

4. The system could not reduce bacterial levels in raw Ohio River water, or in waters containing both bacteria and iron or sulfide, to acceptable levels.

5. The system was effective in killing Polio Type 1 virus spiked into dechlorinated Cincinnati tap water.

6. The system was able to reduce the Threshold Odor Number (TON) of waters having a chloro-phenolic or sulfide odor, but had no effect on water spiked with geosmin.

7. With the exceptions of color, turbidity, iron and manganese, the system had little effect on the routine trace element and other chemical parameter tests performed by the Testing Agent on drinking water samples.

8. The ozone content of the air near the system when in operation exceeded the recommended threshold limit for continuous exposure to ozone of 0.1 ppm in 27% of the 87 tests where it was measured.

9. Different ozone generator coils within the unit failed after 10½, 13 and 38-3/4 hours of operation. At the end of the test program, 2 coils were still operating after 38 and 18 hours, respectively.

Alron Model 45 Portable Water Purifier

1. Testing of this unit was not completed as all 10 units provided by the Innovator failed during the testing program.

2. Limited data, of questionable validity because of the uncertain operating condition of any of the units, is presented on operating parameters and iron, manganese, organics and apparent color removal.

INTRODUCTION

This report contains the laboratory verification test results obtained by the Testing Agent on two drinking water ozone treatment devices manufactured by the Innovator. The testing was financed through a grant to the Testing Agent from the Foundation, as detailed in a copy of the Test Agreement contained in Appendix A. This report has been prepared in compliance with Section III-A-1, Special Conditions, of the Test Agreement.

In general, the verification testing program was conducted as described in a copy of the Test Protocol in Appendix B. Two major exceptions to this are:

1. Testing of the Alron Model 45 Portable Water Purifier was not completed, as all 10 units provided by the Innovator failed during the testing program. All further testing of the Model 45 was stopped after failure of the tenth unit. Limited data, of questionable validity, because of the uncertain operating condition of any of the units, is presented below.

2. No verification testing of the Alron Model WPCF (4 gpm) Water Purifier with Cartridge Filter Model CF was conducted. The Testing Agent was notified by letter dated 1/25/74 that the Innovator intended to drop this model from their product line because of an increase in labor and material costs for the cartridge filter arrangement.

As noted in Section B.7 of the Test Protocol, verification testing, as described herein, does not imply "Approval" or "Endorsement" by the Testing Agent of the devices tested. The USEPA was, in the real sense, "hired" by the National Science Foundation to act as a "testing laboratory" to test certain products. In keeping with our understanding of the proper function

of a testing laboratory, we have reported our test methods and results and have refrained from making either positive or negative comments about the products tested. Thus, it is left to the reader to determine the efficacy of the devices tested in terms of his own needs.

Further, verification testing, as described herein, does not apply "Approval" by the Testing Agent of the concept of allowing untrained persons to individually treate their own drinking water supplies for the removal of chemical or microbiological agent· that may be hazardous to their health. This is particularly true in cases where a continuing program of testing the treated water is not practiced to insure that the removal of the contaminant(s) is maintained under all conditions of use of the treatment device.

Alron Model WP Water Purifier with Model AF Automatic Bachwash Filter (now marketed as Model No. WP-560)

Manufacturers specifications for this water treatment device are contained in Appendix C. Test procedures for this device are outlined in Section E.1 of the Test Protocol (Appendix B). Modifications to this test procedure are given below in the appropriate parameter sub-sections. A complete Test Log is presented in Appendix D.

Figure No. 1 is a sketch of the experimental set-up. In normal operation, Cincinnati tap water was passed through the Model WPCF Purifier to reduce its ozone demand. Model WPCF effluent was collected in a 100-gallon stainless steel tank, where it was mixed for 2 hours to dissipate any dissolved ozone residual. This 100-gallon batch of water was then spiked with an appropriate concentration of the contaminant and stirred for 15 minutes before collection of an influent sample.

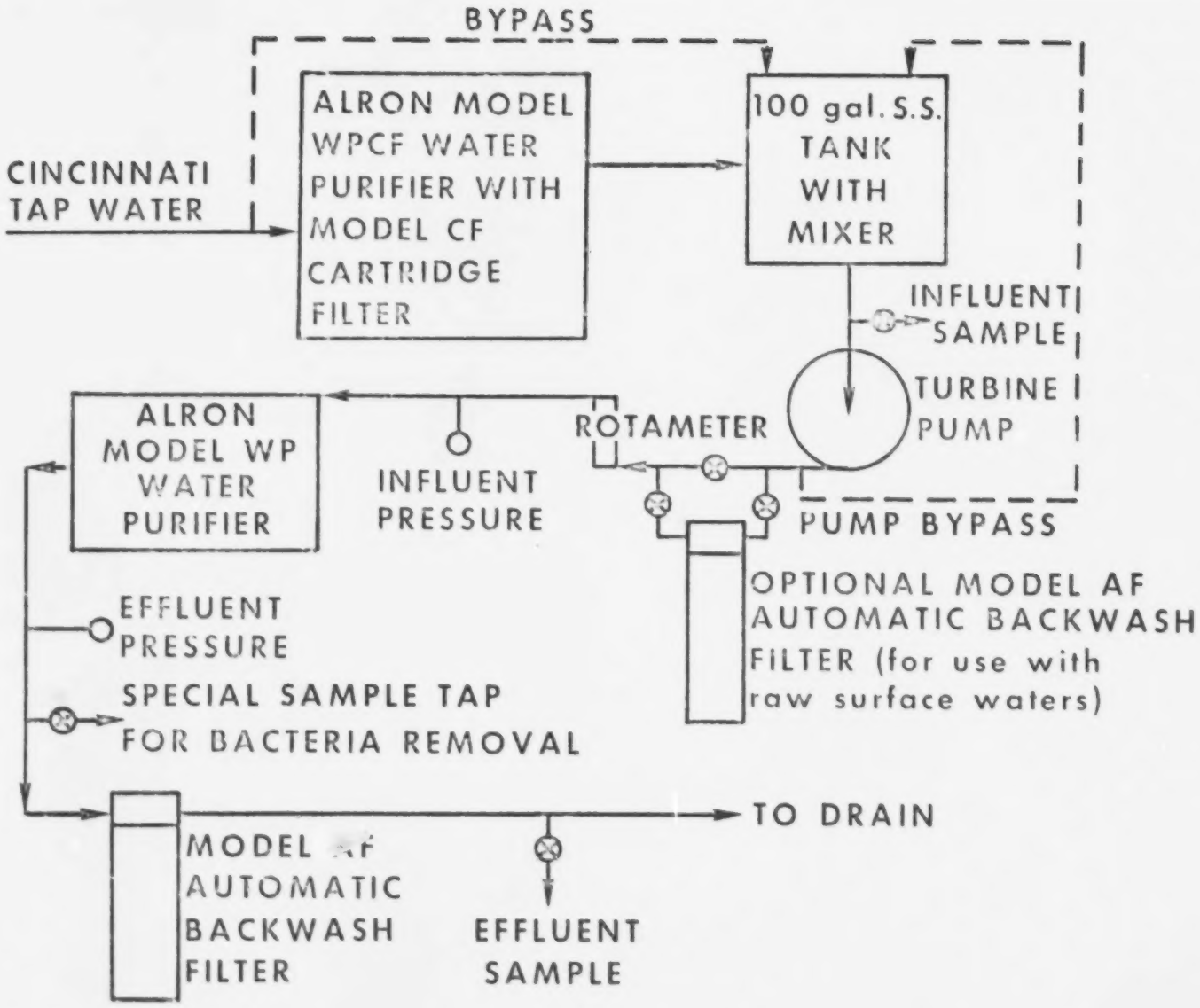

FIGURE 1 EXPERIMENTAL SET-UP FOR TESTING THE ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

The turbine pump and Model WP Purifier were then started and allowed to operate 15-20 minutes to establish normal operating conditions before collection of the effluent sample. During this time period, data was collected on:

Water temperature: influent

Water temperature: effluent

Water pressure: influent

Water pressure: effluent

Water flowrate

Air temperature

Air relative humidity

Ozone in the air near the device

Dissolved ozone in the effluent

At the completion of a test run, all lines and tanks were flushed with Cincinnati tap water. The Model AF Filter(s) were backwashed with either Cincinnati tap water or Model WP effluent.

1. Miscellaneous Operating Parameters

Total contact times for the Model WP Purifier plus Model AF Filter were calculated by assuming a contact tank volume of 20 gallons and a filter volume of 10 gallons. The contact times at 6, 4 and 2 gpm water flowrates are 5, 7.5, and 15 minutes, respectively.

Gas flowrates (ozone + air) were measured at water flowrates of 6, 4 and 2 gpm by installing a rotameter between the ozone generators and the contact tank. Results of these tests are shown in Table No. 1. Gas flow rates are seen to be constant for a given water flowrate, once operating conditions are established. A slight increase in gas flowrate is noted as water flowrate decreases. This is probably because of changing pressure conditions in the contact tank.

TABLE 1

OZONE-AIR MIXTURE FLOWRATE - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

Time	Water Flowrate, gpm	Rotameter Reading	Gas Flowrate SCFH	SCFM
1030	6.7	63	22.2	0.37
1035	6.1	45	15.6	0.26
1038	6.1	45	15.6	0.26
1040	6.1	45	15.6	0.26
1044	6.1	45	15.6	0.26
1046	6.1	46	16.0	0.27
1047	6.1	45	15.6	0.26
1233	4.0	64	22.6	0.38
1237	4.0	58	20.4	0.34
1239	3.9	58	20.4	0.34
1245	4.0	59	20.8	0.35
1250	4.0	59	20.8	0.35
1255	4.0	59	20.8	0.35
1300	4.0	59	20.8	0.35
1315	2.0	66	23.2	0.39
1320	2.0	67	23.6	0.39
1330	2.0	68	24.0	0.40
1340	2.0	67	23.6	0.39
1350	2.0	68	24.0	0.40
1400	2.0	68	24.0	0.40
1405	2.0	68	24.0	0.40

Ozone concentrations in the ozone-air mixture entering the contact tank were measured by placing both a gas wash bottle containing 400 ml of 2% potassium iodide solution and a rotameter between the ozone generators and contact tank. After exposure to the ozone-air mixture, the KI solution was acidified with 10 ml of 1M H_2SO_4 and titrated to a Thyodene endpoint using N/10 sodium thiosulfate.

Table No. 2 shows the results of these ozone concentration tests. The concentrations for the 6 and 4 gpm tests appear equal, once operating conditions were well established, but are much lower during the 2 gpm test. Gas flowrates are lower for a given water flowrate than shown in Table No. 1, because of the presence of the gas wash bottle in the sampling train.

In 55 of the test runs for the Model WP, dissolved ozone concentrations in the effluent of the Model AF Filter were measured using the amperometric titration method of Dailey and Morrow[1]. This method was used as it permits determination of the ozone residual in the presence of the residual chlorine in Cincinnati tap water.

In this method, two 200 ml samples are collected. The first contains 1 ml each of pH 7 buffer and 5% KI, and when titrated with 0.00564N phenylarsene oxide solution, yields the sum of the ozone and chlorine residuals. The second sample, containing 1 ml of pH 7 buffer, is treated with 2 ml of 1N ammonium hydroxide, which reacts with ozone and removes it from the sample. Following this, 1 ml of 5% KI solution is added and the sample is titrated for the remaining chlorine residual. Dissolved ozone is then determined by the equation:

$$\text{ml PAO } (O_3 + OCl^-) - \text{ml PAO } (OCl^-) \times 0.675 = \text{mg/l dissolved ozone}$$

Table No. 3 contains the results of the dissolved ozone determinations. Values for the 2 gpm tests appear to be lower. The reason for this is unknown.

During 86 of the test runs, data were collected on air temperature, air relative humidity and the ozone concentration in the air near the Model WP unit while it was operating. Air temperatures were measured with a mercury thermometer. Air relative humidity was measured with a Bendix Model 566 Psychrometer. Ozone concentrations in the air near the unit were measured using a Mine Safety Appliances Co. universal test kit with ozone detector tubes calibrated over the range 0.05 to 5.0 ppm ozone in air.

TABLE 2

OZONE CONCENTRATION IN OZONE-AIR MIXTURE - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

Test No.	Water Flowrate, gpm	Gas Flowrate, scfm	Ozone Concentration, mg/l	Remarks
1	6.0	0.22	5.8	Test run 5 min. after start of unit
2	6.0	0.22	5.5	Test run 15 min. after start of unit
3	6.0	Lab Accident		Test run 5 min. after start of unit
4	6.0	0.22	5.8	Test run 15 min. after start of unit
5	4.0	0.29	4.8	Test run 5 min. after start of unit
6	4.0	0.29	5.7	Test run 15 min. after start of unit
7	2.0	0.33	4.3	Test run 5 min. after start of unit
8	2.0	0.33	4.4	Test run 15 min. after start of unit

TABLE 3

EFFLUENT DISSOLVED OZONE CONCENTRATIONS - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

Water Flowrate, gpm	Number of Test Runs	Effluent dissolved ozone conc., mg/l		
		Maximum	Minimum	Average
6	34	1.15	0.09	0.56
4	11	1.28	0.04	0.71
2	10	0.73	0.02	0.43

Table No. 4 contains the data collected for these parameters. Air temperatures are well within the 35°F to 120°F (1.7°C to 47.2°C) operating range recommended (see Appendix C).

TABLE 4

AIR TEMPERATURE, RELATIVE HUMIDITY AND OZONE CONCENTRATION IN AIR NEAR THE OPERATING UNIT - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

Parameter	No. of Test Runs	Value or Concentration Average	Range	Remarks
Air temperature	86	20.2°C	15.0-24.5	
Air relative humidity	86	35%	20-80	
Ozone concentration in air near operating unit				Measured with test kit pump on top of unit
	45	< 0.05		
	18	0.07	0.05-0.1	
	24	0.72	0.2-2.5	
Ozone concentration in air near outlet of ozone catalyst tube				Measured with test kit pump at outlet of ozone catalyst tube
	3	1.1	0.3-2.5	
	2	>5.0	-	

The maximum relative humidity specification of 70% (see Appendix C) was exceeded only twice in the 86 tests where it was measured.

A recommended threshold limit value of 0.1 ppm for continuous exposure to ozone has been established[2]. The data in Table No. 4 show that this value was exceeded in 27% of the tests where the test kit pump was placed on top of the unit when it was operating. All tests at the ozone catalyst tube outlet exceeded this value, although direct human exposure at this point is unlikely.

Water temperature rise and pressure drop across the unit was monitored in a total of 86 test runs at 2, 4, and 6 gpm. Water temperatures were measured in the 100 gal. tank influent tank and in the sand filter effluent samples. Pressures were measured immediately up and downstream of the Model WP as shown in Figure No. 1.

This data is presented in Table No. 5. As expected, the temperature rise increases (longer residence time in system) and pressure drop decreases as flow decreases.

TABLE 5

WATER TEMPERATURE RISE AND PRESSURE DROP - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

Water Flowrate, gpm	No. of Test Runs	Temperature Rise, °C Average	Range	Pressure Drop, psig Average	Range
6	55	0.9	0-3.0	8.6	4-13
4	16	1.5	1.0-3.0	6.1	5-8
2	15	1.8	1.0-3.0	2.9	2-3

2. Iron Removal

Figure No. 2 shows the results of 6 runs using iron (dosed as ferrous ammonium sulfate) as the contaminant. Iron concentrations were determined by atomic absorption spectroscopy. No attempt was made to reach the 30 mg/l Fe dose called for in the Test Protocol, as the unit would only remove 30% of the iron present at approximately ¼ of that dose. Also, difficulty was encountered in keeping ferrous iron in solution in Cincinnati tap level above the maximum concentration shown.

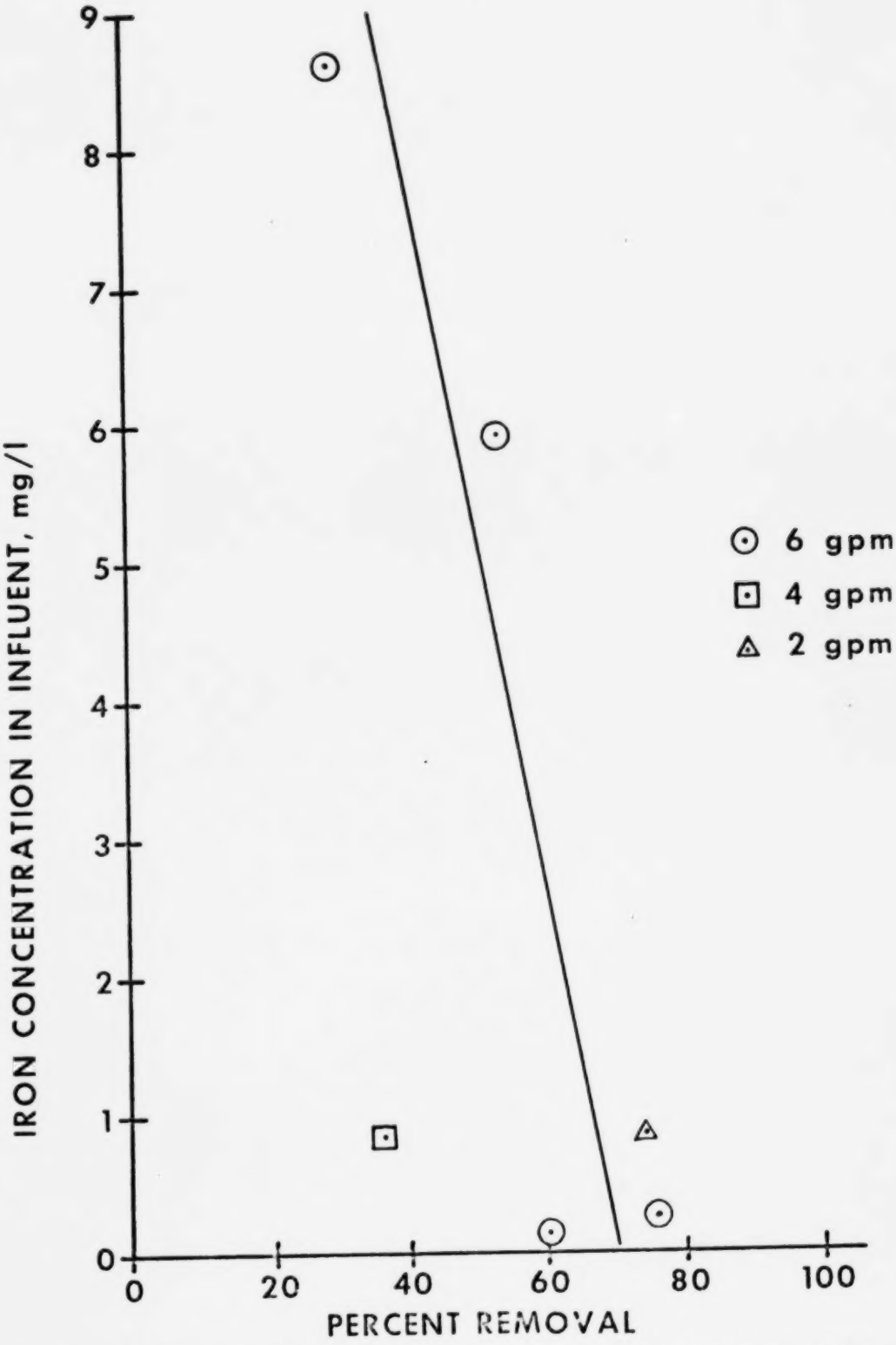

FIGURE 2 IRON REMOVAL—ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

The data show a clear trend of improved removal at lower influent iron concentrations. The runs at lower flowrates show no improvement over the trend of the data for 6 gpm.

3. Total Sulfide Removal

Figure No. 3 shows the results of 4 runs using total sulfide (dosed as hydrogen sulfide) as the contaminant. Hydrogen sulfide was added to the 100 gal. dosing tank (see Figure No. 1) by first bubbling the gas into 15 liters of distilled water in a 5 gal. container for varying periods from 7½ seconds to 2 minutes. This solution was then poured into the dosing tank containing pre-ozonated Cincinnati tap water and the entire contents stirred for 15 minutes.

Total sulfide concentrations were determined by both the titrimetric (iodine) method[3] and a Hach HS-6 Hydrogen Sulfide Test Kit. Because the upper limit of this kit is 3.0 mg/l, most samples had to be diluted, a fact that contribued to the analytical error.

As with iron, removal efficiencies improved as total sulfide concentrations decreased. If only the titration method data are considered, improved removal efficiency is shown in the test at 2 gpm.

4. Manganese Removal

Figure No. 4 shows the results of 5 runs using manganese (dosed as manganous sulfate) as the contaminant. Manganese concentrations were determined by atomic absorption spectroscopy.

Again, as with iron and total sulfide, removal efficiency improves at lower manganese concentrations. No improvement at lower flowrates is noted.

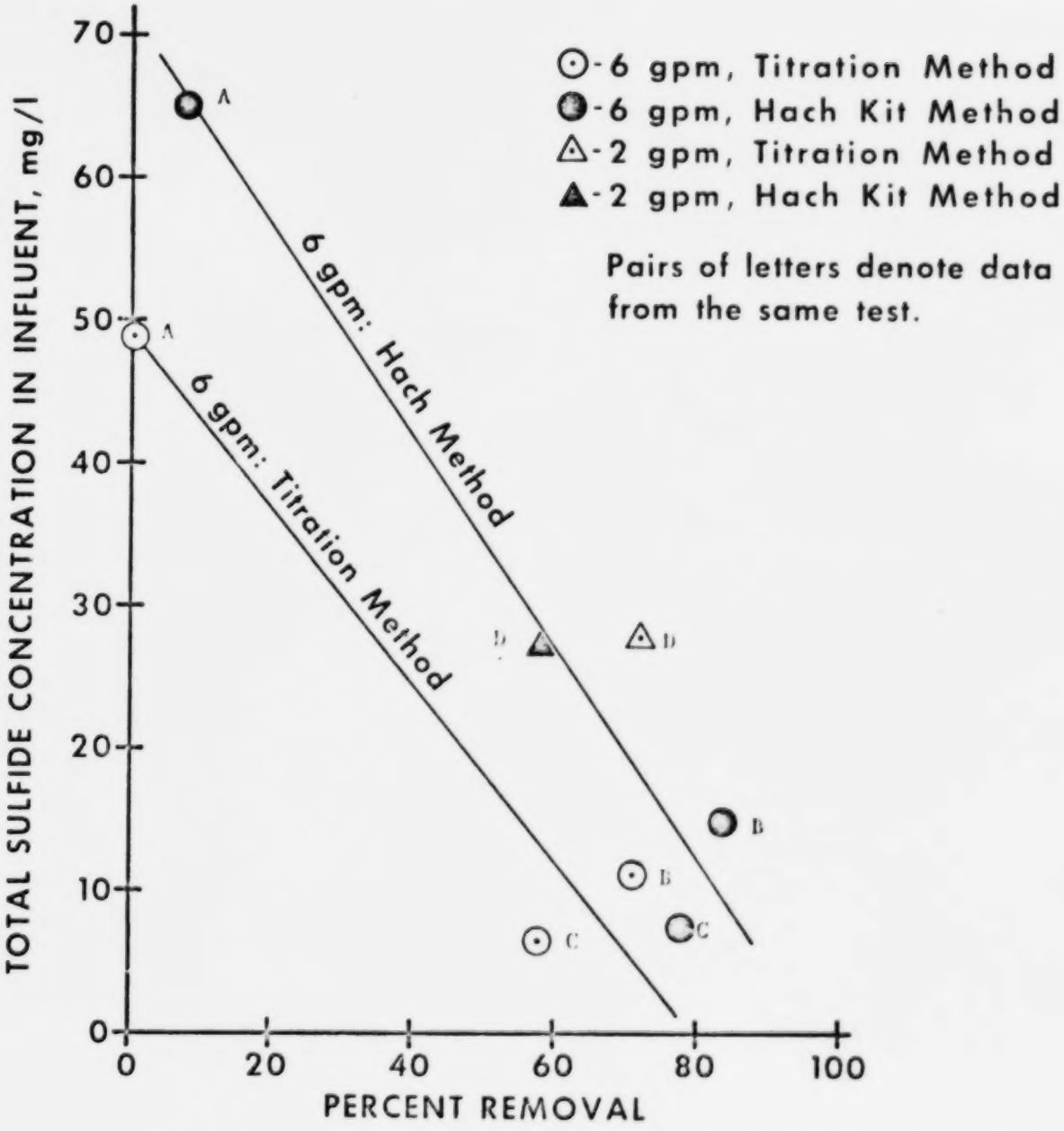

FIGURE 3 TOTAL SULFIDE REMOVAL—ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

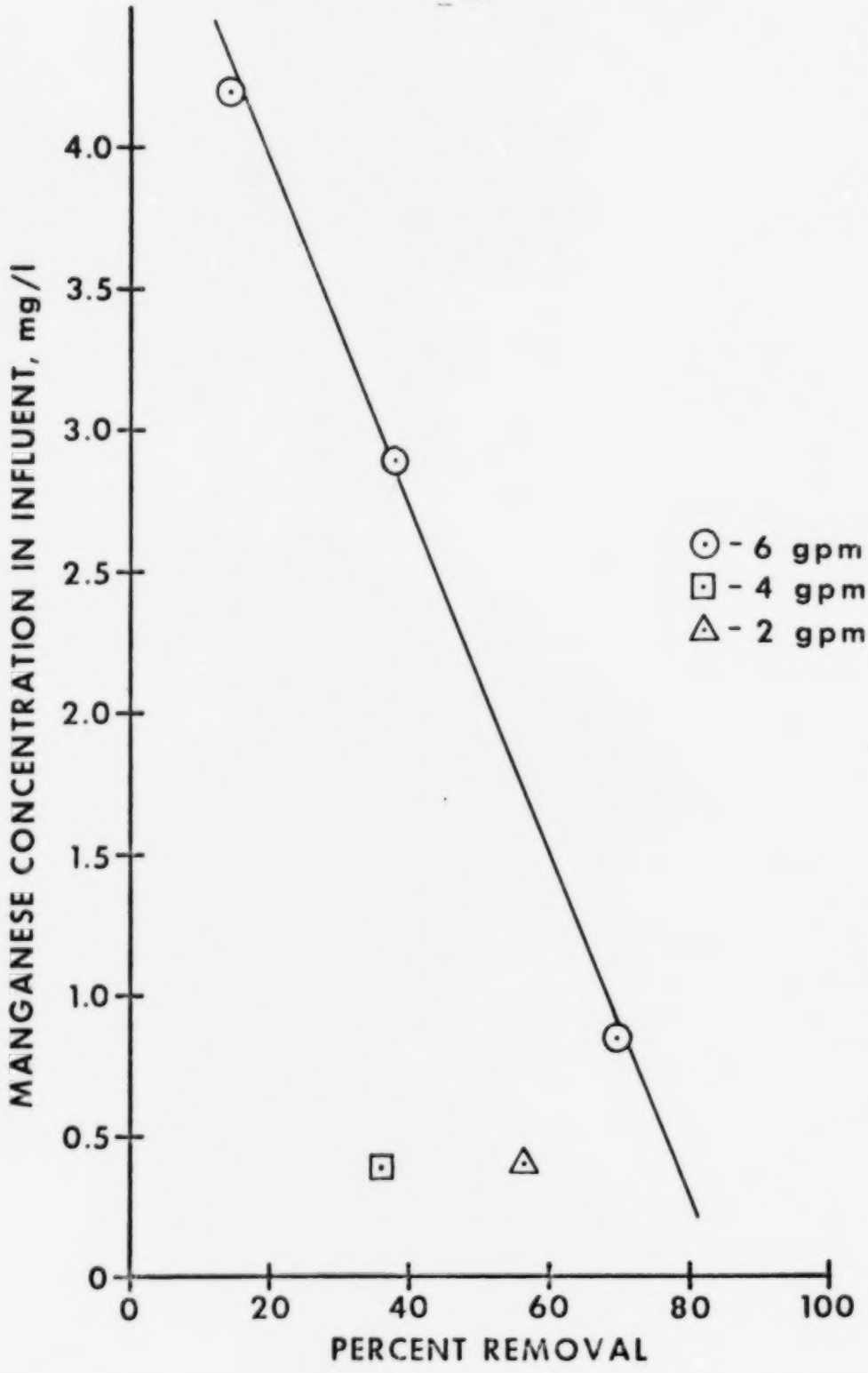

FIGURE 4 MANGANESE REMOVAL—ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

5. Removal of Organic Compounds

In the discussion that follows, "percent removal" of a specific organic compound means the "percent reduction" in the height of a specific peak on a gas chromatogram. One should not infer that the portion removed has been oxidized by the ozone all the way to carbon dioxide and water and thus lost from the system. Rather, quite probably (as shown later in the case of styrene) much of the original compound (particularly the carbon) may remain in the system in the form of oxidation products of the original compound.

a. Dieldrin

Percent removals for Dieldrin, a common pesticide, are shown in Figure No. 5. The analytical procedure for Dieldrin was:

1) collect 1 gal. influent and effluent samples in specially cleaned containers,

2) remove 2-1 liter samples from each container for duplicate extraction and analysis,

3) extract each 1 liter portion for 2 minutes with 3-60 ml volumes of 15% methylene chloride in hexane,

4) combine the extracts and concentrate to about 10 ml using a Kuderna-Danish apparatus and a hot water bath,

5) analyze the concentrate in a gas chromatograph with an electron capture detector and a column packing of 1.95% SE30 + 1.75% SP2401 on gas chrom Q.

The results for Dieldrin show that removal efficiency is relatively constant and is unaffected by either influent concentration or flowrate. The explanation of this is not known at this time.

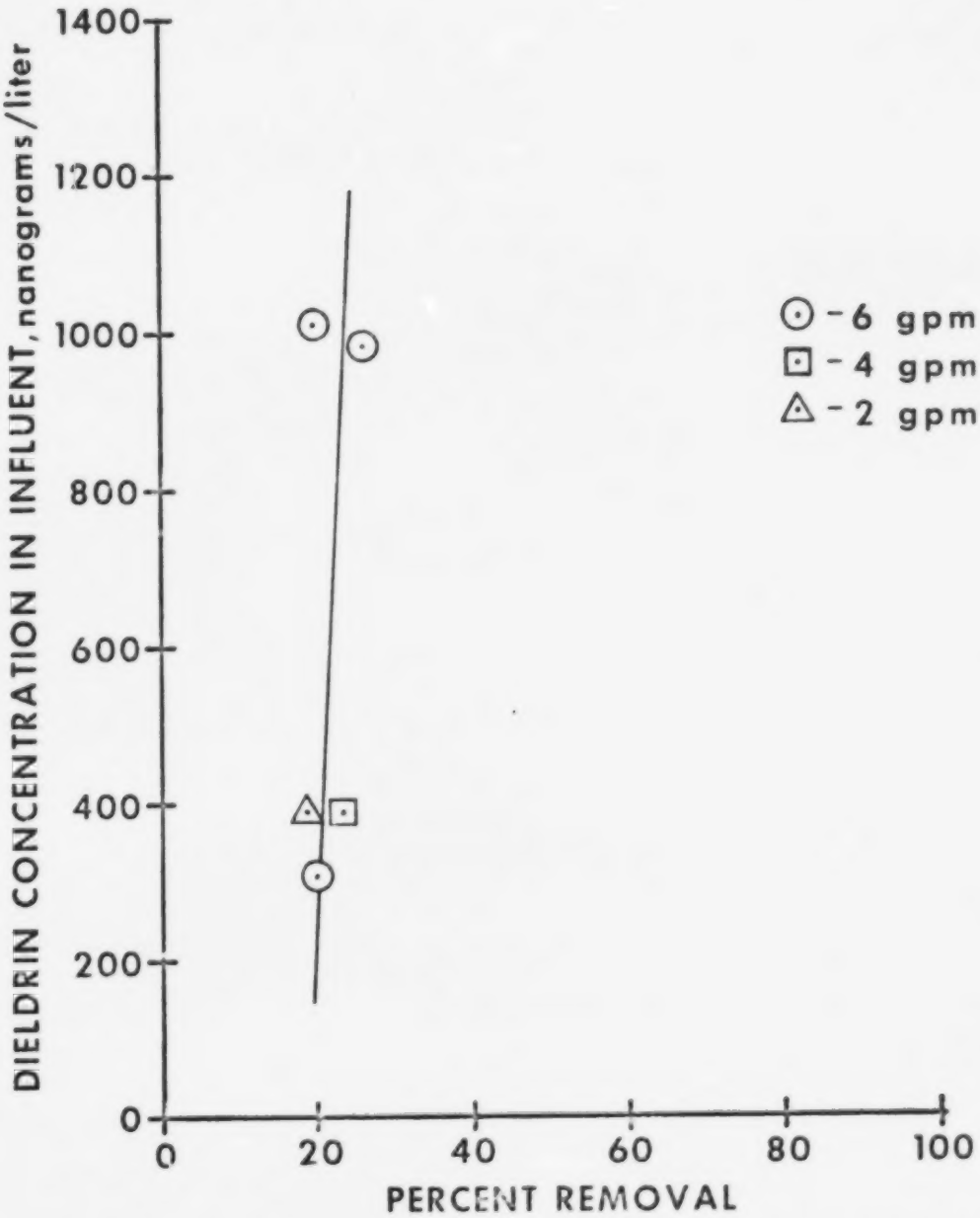

FIGURE 5 DIELDRIN REMOVAL—ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

b. Styrene, Ethylbenzene and 1,2 Dichloroethane

These compounds were selected from those known to cause taste and odor problems or a human health hazard in drinking water. In the case of the Model WP Purifier, these compounds were tested individually, rather than in combination, as with the portable unit. Analysis was by extraction of a 10 ml water sample wtih carbon disulfide, followed by gas chromatographic analysis of the extract using a flame ionization detector.

Figure No. 6 shows the results for styrene. Because styrene was completely removed at all concentrations tested at 6 gpm, no other tests were conducted at lower flowrates.

Ethylbenzene removals are shown in Figure No. 7. With 2 exceptions, all removal data falls in the range of 40 to 60 percent, regardless of influent concentration of flowrate.

Removals of 1,2 Dichloroethane are shown in Figure No. 8. A much lower range of removal percentage than for styrene or ethylbenzene is shown for this compound. Most of the data falls in the range of 4 to 13 percent, regardless of influent concentration or flowrate. A slight improvement in removal efficiency is noted for very low concentrations tested at 6 gpm.

With regard to the case of removal of the individual compounds with ozone, the expected trend was observed. Styrene is an aromatic molecule bearing an unsaturated substituent (vinyl group) which is subject to facile attack with splitting by ozone. Ethylbenzene is likewise an aromatic compound but the aromatic ring bears a saturated (ethyl) substituent. The ethyl group is not subject to facile attach as was the vinyl group. Ozone attack can, however, occur on the aromatic ring, but this reaction would be expected to proceed more slowly than the splitting of the vinylic double bond. Reaction conditions within the device are not known sufficiently well to explain the kinetics of

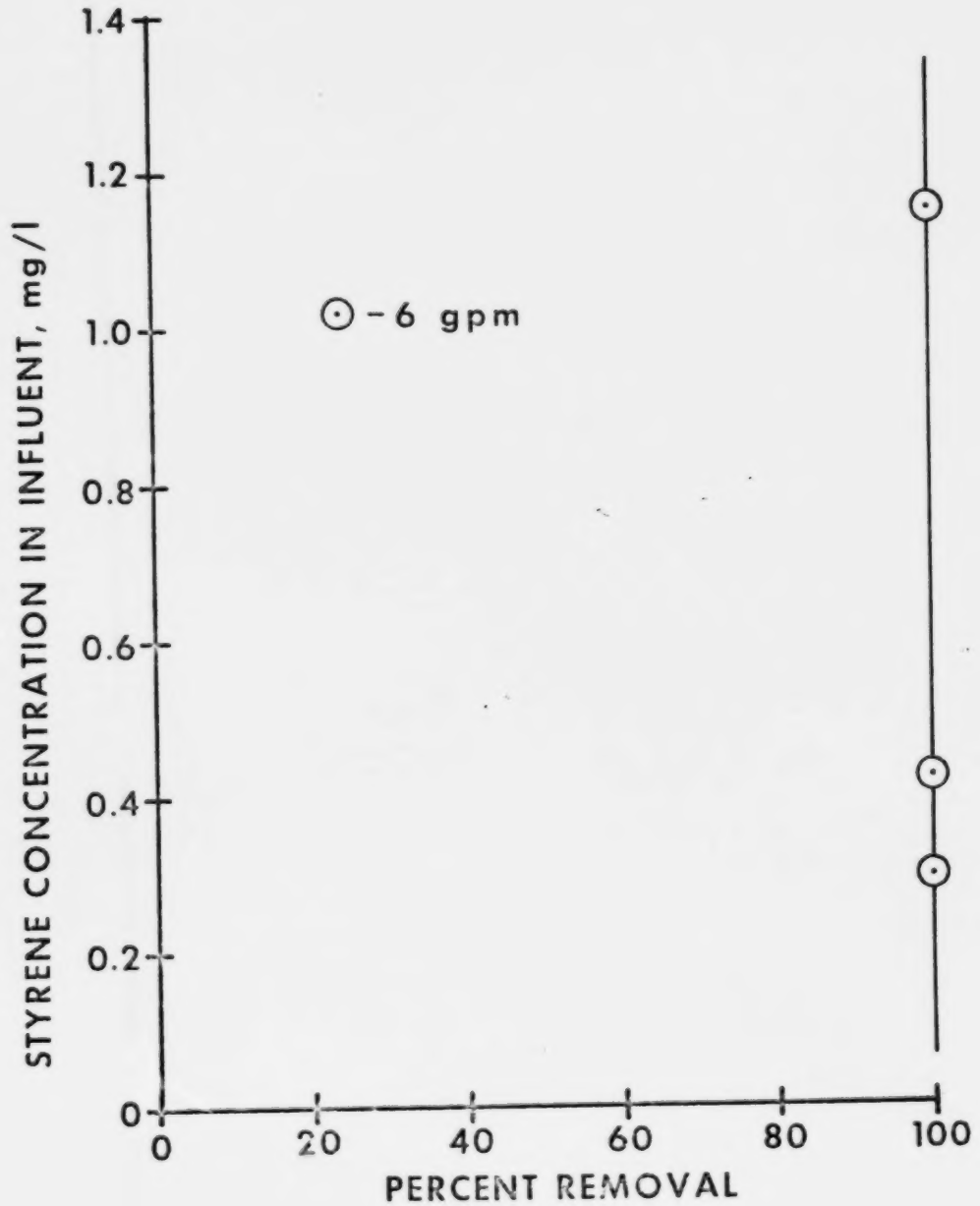

FIGURE 6 STYRENE REMOVAL-ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

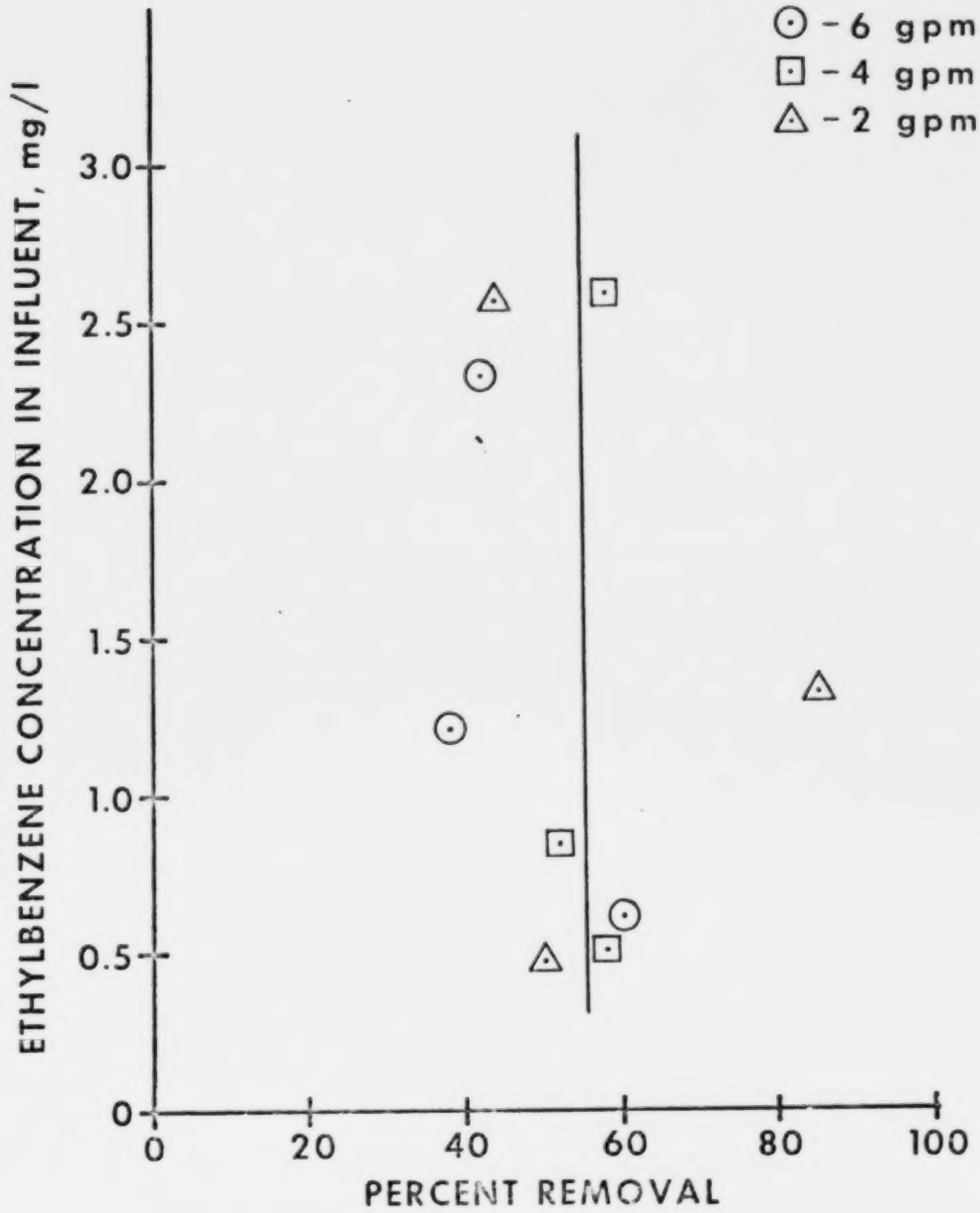

FIGURE 7 ETHYLBENZENE REMOVAL—ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

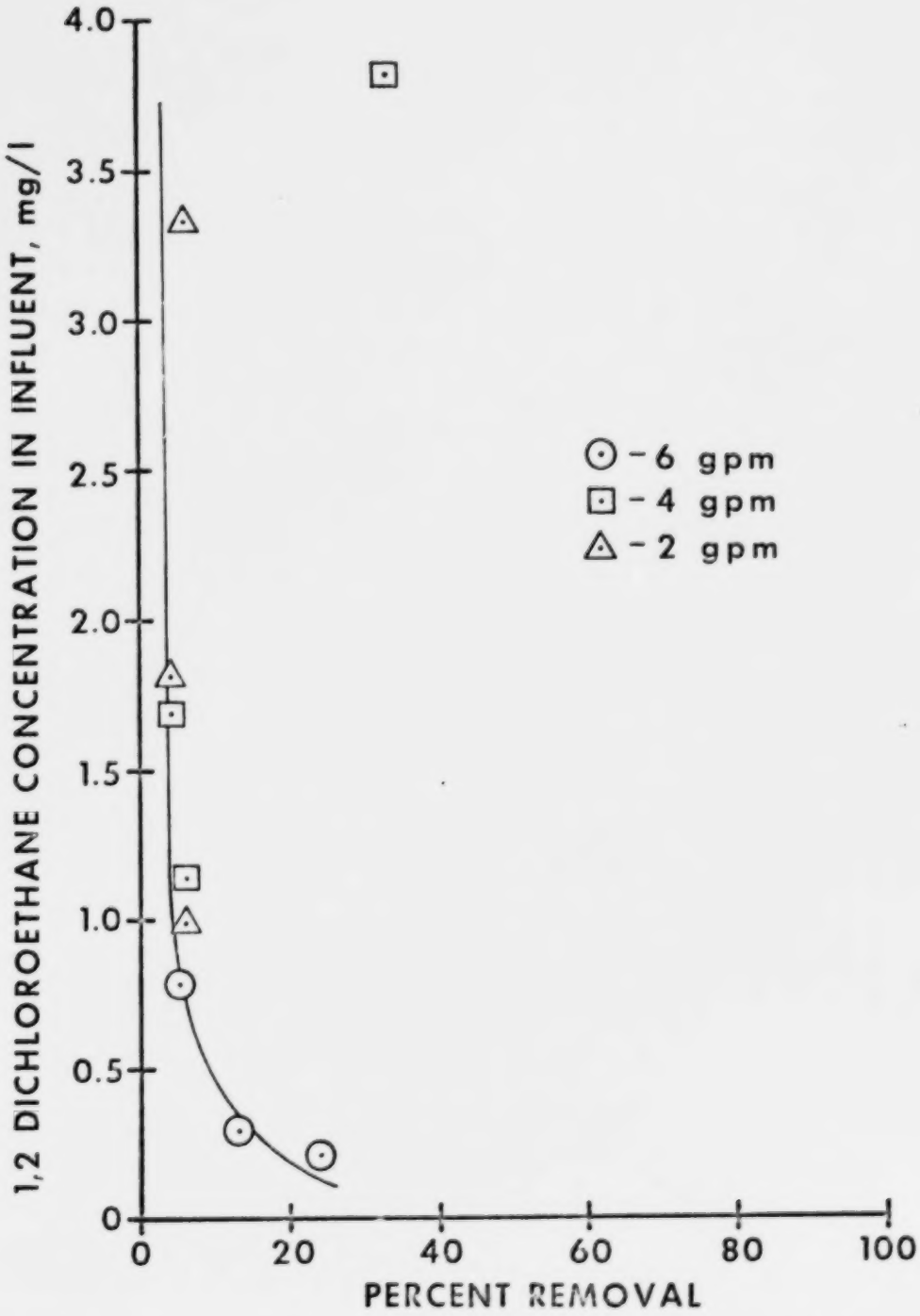

FIGURE 8 1,2 DICHLOROETHANE REMOVAL— ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

the attack of ethyl benzene by ozone. Rate of attack on the aromatic ring is apparently proportional to initial concentration of ethylbenzene giving a relatively constant percentage removal.

1,2-Dichloroethane contains no point of facile ozone attack, and therefore removal efficiency would be expected to be low.

c. Linear Alkyl Sulfonate (LAS)

This anionic-type surface active material was selected as it is the predominant material in the current detergent market. Concentrations of LAS were determined by an automated Methylene Blue Active Substances (MBAS) procedure[3] using a Technicon AutoAnalyzer.

Figure 9 shows the removal results for LAS. Although the removals are quite low, a slight trend of improved removal efficiency at the higher influent concentrations tested is observed.

6. Changes in General Organic Parameters

Although not called for in the Test Protocol, limited studies were conducted on three general organic parameters that have potential as performance monitors for the removal of organic compounds. The three parameters selected are: Carbon-Chloroform Extract (CCE-m), Total Organic Carbon (TOC), and the Rapid Fluorometric Method (RFM). All these parameters are being used by the Testing Agent in their ongoing research on the removal of organic compounds from drinking water.

CCE-m concentrations were determined using the method of Buelow, et al.[4] One hundred gallon batches of influent to and effluent from the Model WP Purifier were prepared or processed for use with this method.

TOC analyses were made on a Phase Separations, Ltd. (United Kingdom) Aqueous Carbon Analyzer. This instrument, which has excellent low carbon level sensitivity, oxidizes aqueous carbon to carbon dioxide, followed by reduction to methane with detection in a flame ionization detector. Samples of 75 ml were acidified and purged to remove carbonates as carbon dioxide prior to analysis.

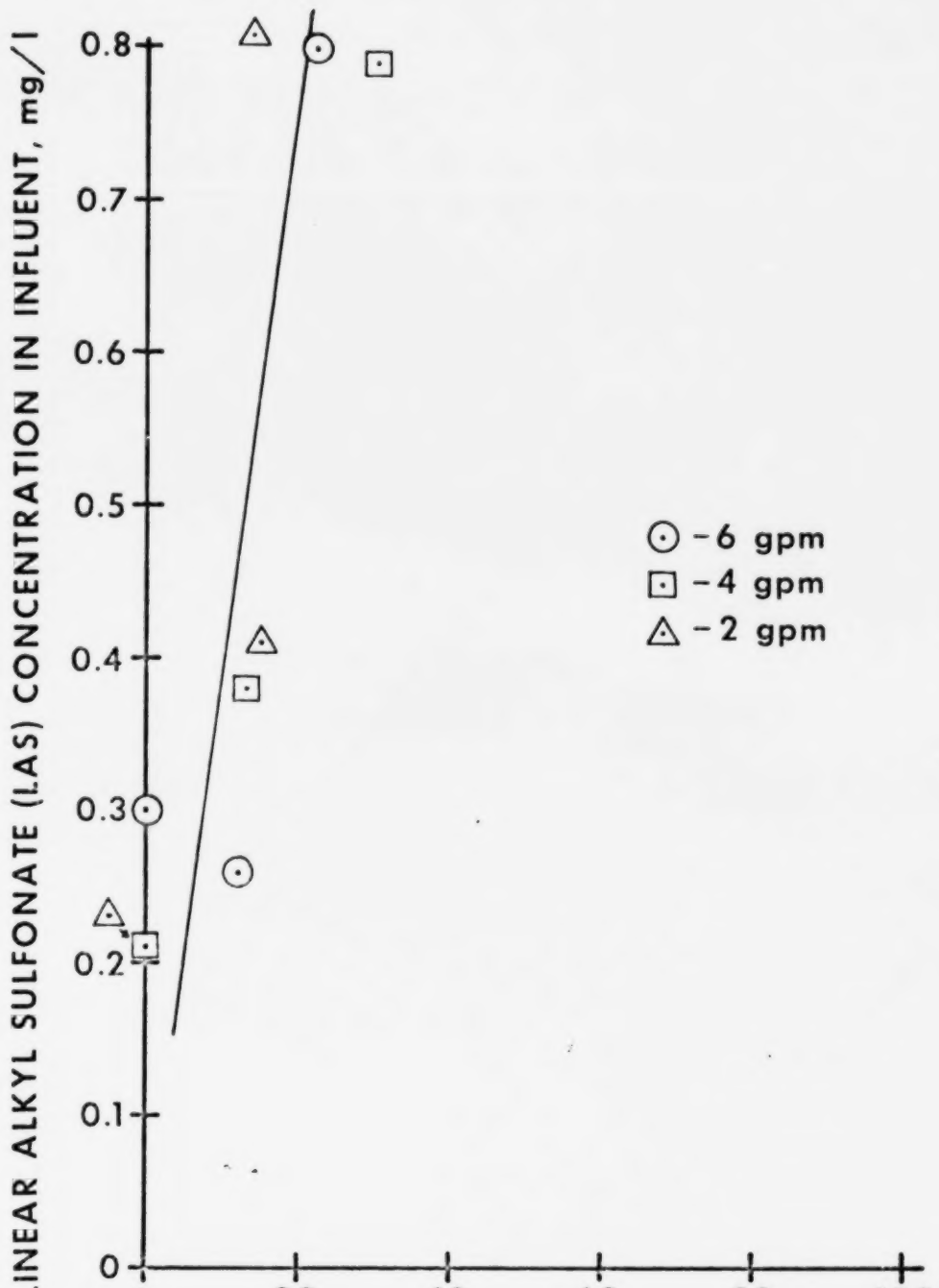

FIGURE 9 LINEAR ALKYL SULFONATE (LAS) REMOVAL—ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

RFM analyses were made on a Perkin-Elmer Model MPF-3L Fluorescence Spectrophotometer according to the method of Silva[5]. His work indicates a strong positive correlation between RFM and CCE-m for the waters he analyzed.

Table No. 6 shows the results obtained for 1-CCE-m only test and 3-CCE-m-TOC-RFM comparative tests run at different flowrates. In each test, unspiked Cincinnati tap water (not pre-ozonated) was used as the Model WP influent. The effluent was collected in a second 100 gal. tank, stirred for 2-3 hours and allowed to stand overnight to dissipate dissolved ozone before sampling.

Although the data in Table No. 6 are very limited, several observations may be made:

a. In 2 tests, CCE-m was removed, but not TOC. Ozonation apparently oxidized some compounds measured in the influent CCE-m to different compounds not measured by the CCE-m method in the effluent. No carbon was oxidized to CO_2 to be lost from the system, however.

b. The strong positive correlation between CCE-m and RFM found by Silva[3] is not evident. More work needs to be done to define this relationship (if any) for other waters.

c. In Test No. 4, the longer ozone contact time resulting from the 2 gpm flowrate may have removed some carbon (TOC) from the system. An increase in CCE-m is not to be expected, however, as the products of ozone oxidation tend to be more polar compounds not as readily measured by the CCE-m method.[6]

The results of a second series of general organic parameter tests at 6 gpm are presented in Table No. 7. In these tests, unspiked Cincinnati tap water (not pre-ozonated) was first sampled before and after passage through the Model WP Purifier to give background values. A second batch of water was then spiked with one of the specific organic compounds previously tested, and the influent and effluent sampled as before. RFM, TOC and specific organic

TABLE 6

CHANGES IN GENERAL ORGANIC PARAMETERS OF CINCINNATI TAP WATER - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

Test #	Parameter	Influent Concentration	Percent Change*	Test Flowrate	Remarks
1	CCE-m	0.4 mg/l	0	6	
2	CCE-m	0.4 mg/l	-25	6	
	TOC	1.2 mg/l	0	6	House distilled H_2O = 0 mg/l TOC
	RFM	15.5 chart units	-30	6	Run on acidified TOC samples
3	CCE-m	0.3 mg/l	-33	4	
	TOC	1.2 mg/l	0	4	House distilled H_2O = 0 mg/l TOC
	RFM	12.5 chart units	+16	4	Un-acidified sample
4	CCE-m	0.1 mg/l	+100	2	
	TOC	1.2 mg/l	-22	2	House distilled H_2O=- mg/l TOC
	RFM	12.0 chart units	+12	2	Un-acidified sample

*: + denotes an increase in the parameter in the effluent.
- denotes a decrease in the parameter in the effluent.

TABLE 7

CHANGES IN GENERAL ORGANIC PARAMETERS IN CINCINNATI TAP WATER SPIKED WITH SPECIFIC ORGANIC COMPOUNDS - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

(1) Parameter	(2) Unspiked Tap Water	(3) Unspiked Tap Water Model WP Effluent	(4) Percent* Change	(5) Spiked Tap Water	(6) Spiked Tap Water Model WP Effluent	(7) Percent* Change
Test No. 1: Styrene						
RFM, chart units	-	-	-	14.5	15.0	+3
TOC, mg/l	1.4	1.4	0	2.0	1.9	-5
Styrene, mg/l	-	-	-	0.56	0	-100
Test No. 2: Ethylbenzene						
RFM, chart units	21	18.5	-12	20	19	-5
TOC, mg/l	1.2	1.4	0	1.4	1.6	+14
Ethylbenzene, mg/l	-	-	-	0.73	0.43	-41
Test No. 3: 1,2 Dichloroethane						
RFM, chart units	18.5	18	-3	20	17	-15
TOC, mg/l						
Sample 1, 1st anal.	1.5	1.7	+13	1.9	1.5	-21
Sample 1, 2nd anal.	-	1.6	-	1.6	-	-
Sample 2, 1st anal.	1.6	1.5	-6	1.6	1.5	-6
Sample 2, 2nd anal.	-	1.4	-	1.5	1.5	0
1,2 Dichloroethane, mg/l	-	-	-	2.1	0.95	-55

*: + denotes an increase in the parameter in the effluent.
- denotes a decrease in the parameter in the effluent.

analyses were run as described above. CCE-m was not run because of a laboratory backlog.

Observations from these data include:

a. In the styrene test, the increase in TOC, Column 5 - Column 3, (2.0-1.4 = 0.6 mg/l) agrees well with the amount of carbon in the styrene added to the system, as determined by GC (0.56 mg/l styrene x 92% carbon = 0.52 mg/l C).

b. Although GC analysis shows 100 percent of the styrene has been removed, there is little, Column 5 - Column 6, (2.0-1.9 = 0.1 mg/l) reduction in TOC, indicating that most of the styrene carbon is still present in the effluent.

c. In the ethylbenzene test, no increase in TOC is noted in the spiked influent sample, Column 5 - Column 3, although GC analysis confirmed the presence of ethyl benzene in a duplicate sample. Ethylbenzene was suspected as being lost from the TOC sample during the gas purge step for carbonate removal.

d. This suspicion was confirmed during the 1,2 Dichloroethane test. Two replicate samples were each analyzed twice for TOC. A decrease in TOC is seen in 2 of the replicate series as additional gas purging continued, Column 5, indicating a loss of volatile compounds. GC analysis of a replicate spiked influent sample confirmed the presence of 1,2 Dichloroethane initially. When a spiked influent TOC sample was analyzed by GC after extensive gas purging, no 1,2 Dichloroethane was found. Thus, TOC results on removals of volatile organic compounds by this procedure must be viewed with suspicion, unless confirmed by GC analysis.

e. The removals (as measured by GC analysis) of styrene and ethyl benzene are similar to the results shown in Figure Nos. 6 and 7, Column 7. The removal of 1,2 Dichloroethane is substantially higher than values shown in Figure No. 8. The reason for this is unknown.

7. Removals of Bacteria and Virus

A variety of bacteria commonly found in the raw water sources for drinking water supplies were tested in the Model WP Purifier at 6 gpm. In addition, one bacterial species was selected for testing in waters containing hydrogen sulfide or iron. One test run was made with raw Ohio River water (see Table No. 11 for chemical results) and another with Polio virus.

With 2 exceptions, all microbiological analyses were performed in accordance with the membrane filter or standard plate count techniques of Standard Methods.[3] No "standard method" exists for Pseudomonas aeruginosa or Polio virus, so special laboratory techniques were used for these organisms.

Several changes in the normal testing operation were necessary for this test series. Because the chlorine residual in Cincinnati tap water would effect microbiological removals, it was removed by passing the tap water through an activated carbon filter. One hundred gallon batches of chlorine residual-free water were spiked with suspensions of the test organisms and stirred for 15 minutes before collecting the influent sample and starting the test run. To show the effect of the Model AF Filter (either as a filter or as providing additional ozone contact time), an additional sampling tap was installed between the Model WP Purifier and the filter (see Figure No. 1).

Table No. 8 shows the results of the microbiological testing. Conclusions that can be drawn from these data include:

a. The unit was effective in killing Enterobacter aerogenes, Escherichia coli, Pseudomonas aeruginosa, Streptococcus faecalis, Klebsiella sp. and Bacillus subtilus spiked into dechlorinated tap water.

b. B. subtilus spores were not killed by ozone, but numbers were reduced in the Model AF Filter.

TABLE 8

REMOVAL OF BACTERIA AND VIRUS - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

Test #	Test Organism	Spiked Influent Count/vol.(ml)	Model WP Effluent Count/vol.(ml)	Filter Effluent Count/vol.(ml)	Test Method
1	Enterobacter aerogenes	55/ml 380/ml	0/100 6/ml	0/100 2/ml	TC SPC
2	Enterobacter aerogenes	660/ml 970/ml	0/100 21/ml	0/100 11/ml	TC SPC
3	Escherichia coli	220/ml 160/ml 1700/ml	0/50 0/100 35/ml	0/50 0/100 8/ml	TC FC SPC
4	Klebsiella sp.	4100/ml	43/ml	11/ml	SPC
5	Pseudomonas aeruginosa	62/ml 940/ml	0/100 11/ml	0/100 5/ml	Special SPC
6	Bacillus subtilus (spores)	1100/ml	130/ml	48/ml	SPC
7	Bacillus subtilus (spores)	TNTC	140/ml	58/ml	SPC
8	Bacillus subtilus (vegetative cells)	260/ml	13/ml	3/ml	SPC
9	Streptococcus faecalis	3/ml 1300/ml	0/100 14/ml	0/100 13/ml	FS SPC
10	Streptococcus faecalis	14/25 440/ml	0/100 10/ml	0/100 8/ml	FS SPC
11	Enterobacter aerogenes with Hydrogen Sulfide	100/ml 260/ml	TNTC/ml 380/ml	TNTC/ml 150/ml	TC SPC
	Total Sulfide Total Sulfide	23.4 mg/l 36.5 mg/l	- -	11.6 mg/l 9.0 mg/l	Titration Hach
12	Enterobacter aerogenes with Iron	140/ml 2550/ml	TNTC/ml 380/ml	TNTC/10 ml 110/ml	TC SPC
	Iron	0.48 mg/l	0.70 mg/l	0.45 mg/l	AA
13	Raw Ohio River water	80/ml 64/10 27000/ml	1/10 0/50 360/ml	2/25 0/50 110/ml	TC FC SPC
14	Polio type 1 virus	$1.3X\ 10^3$ PFU/ml	1 PFU/100 ml	0 PFU/85 ml	Special

Key: TNTC - Too numberous to count
PFU - Plaque forming units
TC - Total coliform test - membrane filter
FC - Fecal coliform test - membrane filter
FS - Fecal streptococcus test- membrane filter
SPC - Standard Plate Count
Special - Special test not in Standard Methods
Titration - Total sulfide by titration
Hach - Total sulfide by Hach Kit
AA - Atomic Absorption Spectroscopy

c. Bacterial concentrations were not reduced to acceptable levels in raw Ohio River water, nor in waters high in total sulfide or iron spiked with E. aerogenes, possibly because of the ozone demand of the non-bacterial contaminants.

d. The Standard Plate Count was reduced to very low levels in all but the raw river water and the water high in total sulfide and iron.

e. The large reduction in SPC during the two B. subtilus spore tests is not indicative of spores being killed. Rather, it is a reduction in the background count, i.e., vegetative cells, not spores.

f. The unit was effective in killing Polio type 1 virus spiked into dechlorinated tap water.

8. Reduction of Threshold Odor Number

Seven test runs were made at various flowrates to determine the ability of the system to remove odors from drinking water. Three compounds were used to produce odor:

a. Phenol - added to chlorinated tap water in an effort to promote formation of the more odoriferous chlorophenols.

b. Hydrogen Sulfide - odor removal tests were run in conjunction with some of the total sulfide removal tests.

c. Geosmin - a metabolic product of Actinomycetes known to cause taste and odor problems in drinking water.

The results of the Threshold Odor Number (TON) tests are highly subjective. Although the general procedure of Standard Methods[3] was followed, several major departures were necessary:

a. odor flasks were 500 ml wide mouth erlenmeyer flasks covered with aluminum foil.

b. all tests were run at room temperature

c. persons making the odor tests were selected at random from the available staff.

d. an ordinary laboratory was used to conduct the tests.

Table No. 9 contains the results of the tests. The removals shown for phenol added to chlorinated tap water appear to improve at lower flowrates. Hydrogen sulfide was effectively removed at lower concentrations. This is in general agreement with Figure No. 3. The system appeared to have no effect in removing the odor of geosmin. This was confirmed by GC analysis, which showed influent and effluent geosmin concentrations of 4.4 and 4.5 µg/l, respectively.

9. Removal of Apparent Color Caused by Iron or Manganese

During several of the tests for iron and manganese removal, samples were analyzed for the removal of apparent color. Apparent color includes not only the color caused by substances in solution, but also suspended matter.[3]

A Hellige Aqua Tester with a platinum-cobalt scale color comparator wheel was used. The results, presented in Table No. 10, are quite subjective for 2 reasons:

a. the color comparator wheel had no intermediate graduations between 0 and 5 color units.

b. no attempt was made to account for the "hue" of the color as may be done with highly colored waters using other methods[3]; only the intensity of the color was estimated relative to the platinum-cobalt scale.

Because the compounds added to produce color were in their soluble (reduced) forms in the influent samples, very little change in color is noted. During one of the manganese tests, a sample was collected from bacteriological sample tap upstream of the Model AF filter. This sample had a dark amber color. It was noted that the filter seems to remove color, but

TABLE 9

REDUCTION OF THRESHOLD ODOR NUMBER (TON) - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

Test #	Compound added to produce odor	Influent Conc.,mg/l	Test* Media	Flowrate, gpm	Influent TON	Effluent TON	Percent** Change	TON temp, °C	No. of persons on TON panel
1	Phenol	~2.6	1	6	130	90	-31	20.8	4
2	Phenol	~2.6	1	4	40	16	-60	24.0	3
3	Phenol	~2.6	1	2	81	20	-75	22.0	3
4	Hydrogen Sulfide	48.8	2	6	160	250	+56	20.6	3
5	Hydrogen Sulfide	11.3	2	6	181	11	-94	22.0	4
6	Hydrogen Sulfide	6.6	2	6	40	1	-98	22.0	4
7	Geosmin	4.4 ug/l	2	6	181	181	0	26.0	6

*Test Media

1: Cincinnati tap water

2: Cincinnati tap water run through Model WPCF and stirred 2 hours.

XX Percent Change

+ = increase in TON in effluent

- = decrease in TON in effluent

TABLE 10

APPARENT COLOR REMOVAL - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

Compound added to produce color	Influent Conc.,mg/l	Influent Color, units	Effluent Color, units	Flowrate
Iron	8.6	1	1	6
Iron	5.9	2	2	6
Iron	0.26	2	2	6
Iron	0.13	2	2	6
Iron	0.84	4	3	4
Iron	0.85	3	2	2
Manganese	0.39	2	2	4
Manganese	0.41	2	2	2

on occasion will pass a slug of highly colored water. When this condition occurred, it was necessary to consecutively backwash the filter at least 4 times before the filter effluent returned to a more normal color level.

10. Changes in Trace Elements and Other Chemical Parameters

Table 11 contains the results of 6 test runs in which changes in both trace elements and other chemical parameters were investigated. The parameters listed in the Table represent a substantial portion of the routine chemical tests performed by the Testing Agent on drinking water samples from around the nation.

Test No. 1 represents changes that result when Cincinnati tap water that has been pre-ozonated by passage through the Model WPCF Purifier is then passed through the Model WP Purifier. Test No. 2 is a similar test performed on Cincinnati tap water that had not been pre-ozonated. A comparison of

TABLE 11

CHANGES IN TRACE ELEMENTS AND OTHER CHEMICAL PARAMETERS - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER. (All tests run at 6 gpm)

	Test No. 1 Cincinnati tap water pre-ozonated with the Model WPCF Purifier			Test No. 2 Cincinnati tap water (not pre-ozonated)			Test No. 3 Cincinnati tap water (pre-ozonated) pH depressed with H_2SO_4		
Parameter	Influent Conc.	Effluent Conc.	Percent* Change	Influent Conc.	Effluent Conc.	Percent* Change	Influent Conc.	Effluent Conc.	Percent* Change
Turb.,su	0.18	0.27	+50	0.18	0.32	+78	0.2	0.2	0
Color,su	3	3	0	2	3	+50	3	3	0
TDS,mg/l	270	259	-4	246	246	0	262	249	-5
Chloride,mg/l	31	34	+10	30	31	+3	38	30	-21
Sulfate,mg/l	93	98	+5	92	93	+1	103	103	0
Ba, mg/l	0.05	<0.05	-	0.05	<0.05	-	<0.05	<0.05	-
MBAS, mg/l	<0.25	<0.25	-	<0.25	<0.25	-	<0.25	<0.26	-
As, mg/l	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Se, mg/l	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Fl, mg/l	0.3	0.3	0	0.3	0.3	0	0.2	0.2	0
Sp.Cond., umho	440	440	0	434	425	-2	428	436	+2
pH	7.5	7.6	+1	7.7	7.6	-1	7.2	7.2	0
Cr, mg/l	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Ag, mg/l	0.010	0.00	-100	0.00	0.00	-	0.00	0.00	-
Cu, mg/l	0.050	0.050	-	0.009	0.061	+578	0.026	0.061	+135
Mn, mg/l	0.00	0.00	-	0.006	<0.006	-	0.00	0.00	-
Pb, mg/l	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Fe, mg/l	0.032	0.032	0	0.046	0.046	0	0.018	0.039	+117
Co, mg/l	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Cd, mg/l	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Zn, mg/l	0.049	0.49	+900	0.087	0.074	-15	0.101	0.055	-45
Ni, mg/l	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Hg, mg/l	0.0007	0.00011	+57	0.0009	0.0008	-11	<0.0005	<0.0005	0
Nitrate,mg/l	4	5	+25	4	4	0	4	5	+25

TABLE 11 (Contd.)

Parameter	Test No. 4 Cincinnati tap water (pre-ozonated) pH elevated with NaOH			Test No. 5 Raw Glendale Ohio well water			Test No. 6 Raw Ohio River water - additional Model AF Filter used as pre-filter (see Figure No. 1)		
	Influent Conc.	Effluent Conc.	Percent* Change	Influent Conc.	Effluent Conc.	Percent* Change	Influent Conc.	Effluent Conc.	Percent* Change
Turb.,su	0.27	0.22	-18	22	3.2	-85	45	9.2	-80
Color, su	2	2	0	15	5	-67	10	10	0
TDS, mg/l	257	256	-<1	336	339	+1	194	190	-2
Chloride, mg/l	42	32	-24	17	17	-	15	15	-
Sulfate,mg/l	89	88	-1	<25	<25	-	63	66	+5
Ba, mg/l	<0.05	<0.05	-	0.54	0.50	-8	<0.05	<0.05	-
MBAS,mg/l	<0.25	<0.25	-	<0.25	<0.25	-	<0.25	<0.25	-
As, mg/l	<0.005	<0.005	-	0.010	<0.005	-	<0.005	<0.005	-
Se, mg/l	<0.005	<0.005	-	0.005	<0.005	-	<0.005	<0.005	-
Fl, mg/l	0.2	0.2	0	0.2	0.2	0	0.1	0.1	-
Sp.Cond.,μmho	435	435	0	605	600	-1	300	303	+1
pH	8.5	8.4	-1	7.4	7.5	+1	7.2	7.3	+1
Cr, mg/l	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Ag, mg/l	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Cu, mg/l	0.017	0.035	+106	0.00	0.00	-	0.018	0.035	+94
Mn, mg/l	0.00	0.00	-	0.080	0.24	+200	0.23	0.11	-52
Pb, mg/l	0.00	0.00	-	0.034	0.00	-100	0.00	0.00	-
Fe, mg/l	0.032	0.025	-22	2.1	0.44	-79	1.9	0.66	-65
Co, mg/l	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Cd, mg/l	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Zn, mg/l	0.045	0.11	+144	0.037	0.034	-8	0.088	0.085	-3
Ni, mg/l	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
Hg, mg/l	< 0.0005	< 0.0005	-	0.0005	< 0.0005	-	< 0.0005	< 0.0005	-
Nitrate,mg/l	5	5	0	<1	<1	-	5	6	+20

* += increase in effluent, - = decrease in effluent.

effluent concentrations for these two tests shows that pre-ozonation had little effect on most of these inorganic parameters. The reason for the increases shown in Cu, Zn and turbidity is unknown, but could represent internal contamination as these tests were run immediately after the systems were installed.

Test No. 3 and 4 were run with pre-ozonated tap water in which the pH had been adjusted both upward and downward. As no marked changes from normal pH conditions were seen in these tests, further pH adjustment tests were cancelled.

Test No. 5 was run using a local ground-water known to be moderately high in both iron and color. Substantial removal was obtained in both these parameters.

Test No. 6 was run using a local surface water known to contain significant chemical and bacteriological (see Table No. 8) contamination. In this test, a second Model AF Filter was installed as a pre-filter upstream of the Model WP Purifier. Expected removals in Fe, Mn and turbidity are noted.

11 Operating Problems

During the test program, several problems developed in the operation of the Model WP. The principal one was the failure, on several occasions, of the ozone generator coils.

After approximately 38-3/4 hours of operation in the test program, both ozone generator coils originally supplied with the unit failed. The apparent cause of failure was internal shorting. These coils were replaced with one new coil and one used coil from the Model WPCF unit. The used coil had approximately 12 hours of operating time on it when installed in the Model WP.

After installation, the used coil continued to operate for approximately 1 hour before it failed. At this point, all generators on both units were replaced with new coils supplied by the Innovator.

One of these new coils installed on the Model WP operated for approximately 10½ hours before it failed. The 2nd operated for approximately 30 3/4 hours before failure. Each coil was replaced with a new one. These continued to operate (38 hours and 18 hours, respectively) until the end of the test program.

A second, more minor problem was the float valve in the ozone contact tank. One one occasion, this valve stuck in the closed position, causing the air-ozone mixture above the water in the contact tank to spurt out the effluent sample valve when it was opened. On a second occasion, the valve stuck in the open position, causing water to flow onto the floor through the ozone catalyst tube. On both occasions, the faulty valve was replaced, solving the problem.

Alron Model 45 Portable Water Purifier

Manufacturers specifications for this water treatment device are contained in Appendix E. Test procedures for this device are outlined in Section E.3 of the Test Protocol (Appendix B). A minor change from the Test Protocol was made for some test runs. Instead of individually spiking 4 gallon batches of distilled water with the contaminant as noted in Section E.3(b), larger (12 to 17 gallon) batches were spiked, sampled for initial concentration of contaminant, and distributed in 4-gallon lots to the treatment containers.

Because, as noted above and discussed below, all 10 portable units failed during testing, determining the validity of any of the results reported below is impossible. In some cases, failure occurred suddenly during a test run, while in others, progressive deterioration in performance was observed. When a failure occurred, it is noted in the data presentations below as well as in the Test Log found in Appendix F.

1. Ozone Output

After the first portable unit of the original group of 3 received from the Innovator failed during an organics removal test, the remaining 2 units were checked for ozone output concentration and ozone-air flowrate. The results of these tests are summarized in Table No. 12. Ozone concentrations were determined by placing a gas wash bottle containing 400 ml of 2% potassium iodide solution on the ozone outlet line of the unit. After approximately 3 liters of ozone-air mixture had passed through the gas wash bottle (as measured by a wet-test meter), the KI solution was acidified with 10 ml of 1M H_2SO_4 and titrated to a Thyodene endpoint using N/10 sodium thiosulfate. Ozone-air flowrate was determined by noting the time required for approximately 3 liters to pass through the wet-test meter.

TABLE 12

OZONE OUTPUT CONCENTRATION AND OZONE-AIR FLOWRATE - ALRON MODEL 45 PORTABLE WATER PURIFIERS RECEIVED FOR TESTING ON 10/1/73

Unit #	O_3 Output Conc., mg O_3/liter				O_3-Air Flowrate standard liters/hour				
	Number of Tests	Min.	Max.	Avg.	Number of Tests	Min.	Max.	Avg.	Avg. O_3 Yield g/h
1	4	9.7	12.4	10.9	2	14.06	17.56	15.81	0.172
2	4	6.9	7.8	7.4	2	32.24	32.50	32.37	0.240

After reviewing the data in Table No. 12, the Innovator informed the Testing Agent that initial units 1 and 2 were showing signs of early failure. Three more units were sent by the Innovator and tested for ozone output and flowrate in a similar manner. These results are shown in Table No. 13 along with similar test results obtained on the units by the Innovator before shipping.

TABLE 13

OZONE OUTPUT CONCENTRATION AND OZONE-AIR FLOWRATE, ALRON MODEL 45 PORTABLE WATER PURIFIERS RECEIVED FOR TESTING ON 10/18/73

Unit #1

Parameter	Test #1	Test #2	Test #3	Avg.	Alron
O_3 conc.,mg O_3/l	8.3	8.0	7.1	7.8	5.0
Gas flowrate, slph	19.6	23.0	27.7	23.4	51.4
O_3 yield, g/hr	0.163	0.184	0.197	0.181	0.260

Unit #2

O_3 conc., mg O_3/l	7.4	7.6	7.9	7.6	4.6
Gas flowrate, slph	30.7	28.8	28.2	29.5	55.4
O_3 yield, g/hr	0.227	0.219	0.223	0.223	0.253

Unit #3

O_3. conc., mg O_3/l	5.7	5.7	5.7	5.7	4.9
Gas flowrate, slph	38.4	39.2	40.4	39.3	55.4
O_3 yield, g/hr	0.219	0.224	0.230	0.224	0.270

After the failure of the second set of 3 units, testing of the portable model was stopped for about 4½ months. When testing was resumed with a new set of 4 portable models, additional ozone output and flowrate tests were run. The results of these tests are shown in Table No. 14.

TABLE 14

OZONE OUTPUT CONCENTRATION AND OZONE-AIR FLOWRATE, ALRON MODEL 45 PORTABLE WATER PURIFIERS RECEIVED FOR TESTING ON 3/7/74

Parameter	Unit #1	Unit #2	Unit #3	Unit #4	Average
O_3 conc., mg O_3/l	8.4	12.2	10.3	6.8	9.4
Gas flowrate, slph	32.4	18.0	31.8	40.8	30.8
O_3 yield, g/hr	0.273	0.219	0.327	0.277	0.274

Following the first failure in this last group of 4 units during an iron and color removal test, additional ozone output and flowrate tests were performed on the remaining 3 units. As 1 of these units failued during these tests, Table No. 15 contains data from only 2 units.

TABLE 15

OZONE OUTPUT CONCENTRATION AND OZONE-AIR FLOWRATE, 2ND TEST, ALRON MODEL 45 PORTABLE WATER PURIFIERS RECEIVED FOR TESTING ON 3/7/74

Parameter	Unit #2	Unit #4	Average
O_3 conc., mg O_3/l	9.9	12.5	11.2
Gas flowrate, slph	13.8	16.2	15.0
O_3 yield, g/hr	0.136	0.202	0.169

By comparing these data with that in Table No. 8, a significant reduction in gas flowrate and ozone yield is noted. This condition indicates failure is near. In fact, these 2 units failed completely when undergoing similar tests 2 days later.

2. Dissolved Ozone

Tests for dissolved ozone in the water in the treatment container were run on the last set of portable units. The tests were run using a special treatment container containing a sampling port (bulkhead fitting) through the sidewall. After 15 minutes of ozonation, a 500 ml water sample containing dissolved ozone was collected through the sampling port into a gas wash bottle. Care was taken to minimize aeration of the sample. Using nitrogen, the ozone content of the sample was purged into a second gas wash bottle containing 400 ml of 2% KI and titrated as before for the ozone output tests. Table No. 16 contains the data from these tests.

TABLE 16

DISSOLVED OZONE PRODUCTION - ALRON MODEL 45 PORTABLE WATER PURIFIERS RECEIVED FOR TESTING on 3/7/74

Parameter	Unit #1	Unit #2	Unit #3	Unit #4	Average
Air Temp., ^{o}C	22	21	20	19	20
Relative Humidity, %	32	36	52	47	42
Water Temp., ^{o}C	21	21	21	23	22
Dissolved O_3, mg/l	0.55	0.30	0.43	0.60	0.47

3. Ozone in Air Near Operating Portable Units

Ozone concentrations in the air near the operating portable units were measured during six tests of the last set of 4 units. Measurements were made using a Mine Safety Appliances Co. universal test kit with ozone detector tubes calibrated over the range 0.05 to 5.0 ppm ozone in air. The inlet of the air sampling pump was placed approximately 2 to 3 feet from the units.

Results of these tests are shown in Table No. 17. These data show that the recommended threshold limit value for continuous exposure to ozone of 0.1 ppm[2] was exceeded in 58% of the tests.

TABLE 17

OZONE CONCENTRATIONS IN AIR NEAR OPERATION ALRON MODEL 45 PORTABLE WATER PURIFIERS RECEIVED FOR TESTING 3/7/74

Test No.	Unit #1	Unit #2	Unit #3	Unit #4
1	0.10	0.15	<0.05	0.90
2	<0.05	0.15	0.20	0.20
3	0.28	0.25	0.05	0.90
4	0.12	0.30	0.60	0.50
5	0.05	<0.05	0.07	4.0
6	<0.05	<0.05	<0.05	0.07
Average of values ≥0.05	0.14	0.21	0.23	1.2

4. Iron Removal

Table No. 18 shows the results of 4 test runs using iron (dosed as ferrous ammonium sulfate) as the contaminant. Concentrations of iron in the spiked and treated samples were determined by atomic absorption spectroscopy.

TABLE 18

IRON REMOVAL - ALRON MODEL 45 PORTABLE WATER PURIFIER

Initial Iron Conc. mg/l	Conc. of Iron Remaining after Treatment Time Noted, mg/l							
	5 min.		15 min.		30 min.		45 min.	
		Percent Reduction		Percent Reduction		Percent Reduction		Percent Reduction
0.44	0.43	2.3	0.37	15.9	0.38	13.6	0.35	20.4
0.81	0.81	0	0.81	0	0.81	0	0.72	11.1
1.8	1.8	0	1.8	0	1.7	5.6	1.7	5.6
2.7	2.7	0	2.4	11.1	2.6*	3.7	2.7	0

*Unit stopped operating after 20 minutes.

5. Manganese Removal

Table No. 19 shows the results of 2 test runs using manganese (dosed as manganous sulfate) as the contaminant. Manganese concentrations were determined by atomic absorption spectroscopy.

TABLE 19

MANGANESE REMOVAL - ALRON MODEL 45 PORTABLE WATER PURIFIER

Initial Manganese Conc., mg/l	Conc. of Manganese Remaining after Treatment Time Noted, mg/l							
	5 min.		15 min.		30 min.		45 min.	
		Percent Reduction		Percent Reduction		Percent Reduction		Percent Reduction
0.47	0.44	6.4	0.28	40.4	0.29	38.3	0.043	90.8
0.83	0.83	0	0.83	0	0.87	0	0.80	3.6

6. Organics Removal

Table No. 20 shows the results of the first of 2 test runs using a mixture of organic compounds as the contaminant. A single portable unit was used to collect these data. The organic compounds are styrene, ethylbenzene and 1,2 dichloroethane. They were selected as typical compounds known to cause taste and odor problems or a human health hazard in drinking water. Their concentrations were determinated by the extraction of a 10 ml water sample with 1 ml of carbon disulfide. The extract was injected into a gas chromatograph with a flame ionization detector.

TABLE 20

ORGANICS REMOVAL - ALRON MODEL 45 PORTABLE WATER PURIFIER

Compound	Initial Conc., mg/l	Percent Reduction after Treatment Time	
		15 min.	30 min.
Styrene	0.91	100	100
Ethylbenzene	0.87	41.5	62.3
1,2 dichloroethane	2.52	6.2	8.1

Table No. 21 shows additional data for these three compounds for a 2nd test run in which more samples were collected. These data were collected from 3 portable units at the following time intervals:

Unit No. 1: 0, 5, 20 and 35 minutes

Unit No. 2: 0, 10, 25 and 40 minutes

Unit No. 3: 0, 15, 30 and 45 minutes

As noted in the Table, no data was obtained at 45 minutes, as Unit No. 3 stopped operating after the 30 minute sample. The erratic data for ethylbenzene, particularly at 15 and 30 minutes, may have resulted from the impending failure of the unit.

TABLE 21

ORGANICS REMOVAL - ALRON MODEL 45 PORTABLE WATER PURIFIER

Compound	Initial Conc.,mg/l	Percent Reduction after Treatment Time 5 min.	10 m.	15 m.	20 m.	25 m.	30 m.	35 m.	40 m.	45 m.
Styrene	0.91	67.5	100*	100*	100*	100*	100*	100*	100*	**
Ethylbenzene	0.87	6.3	4.4	27.6	5.2	25.4	36.0	30.5	53.9	**
1,2 dichloroethane	2.52	0	0	0	0	0	0	1.6	43.6	**

* Below Detection Limit
** Unit stopped between 30 and 45 minutes.

7. Removal of Apparent Color Caused by Iron

During the iron removal tests summarized in Table No. 18, data were also collected on the removal (in this case actually an increase) of apparent color due to iron in the treated water samples. Apparent color was determined using a Hellige Aqua Tester with a platinum-cobalt scale color comparator wheel with a maximum reading of 50 color units. The highly subjective nature of these apparent color determination is discussed above in Model WP - Section 9.

TABLE 22

APPARENT COLOR REMOVAL - ALRON MODEL 45 PORTABLE WATER PURIFIER

Initial Color, cu	Color after Treatment Time Noted, cu 5 min.	15 min.	30 min.	45 min.
0	5	22	20	28
0	12	27	>50	>50
3	0	28	>50	>50
2	2	2	10*	2

*Unit stopped operating after 20 minutes.

8. Portable Unit Failures

Table No. 23 lists the approximate total operating times of each of the 10 portable units after receipt by the Testing Agent. All units failed (or approached failure) by stopping to pump the ozone-air mixture into the treatment container.

TABLE 23

TOTAL OPERATING TIME BEFORE FAILURE - ALRON MODEL 45 PORTABLE WATER PURIFIERS

Unit #	Total Operating time, hours	Date Received for Testing	Remarks
1	1.6	10/1/73	Returned to Innovator - near failure
2	1.3	10/1/73	Returned to Innovator - near failure
3	1.6	10/1/73	Complete failure
1	0.9	10/18/73	Complete failure
2	0.3	10/18/73	Complete failure
3	4.8	10/18/73	Complete failure
1	3.1	3/7/74	Complete failure
2	3.4	3/7/74	Complete failure
3	2.6	3/7/74	Complete failure
4	4.5	3/7/74	Complete failure

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3. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, New York, N.Y., (13th ed., 1971).

4. Buelow, R.W., Carswell, J.K. and Symons, J.M., "An Improved Method of Determining Organics by Activated Carbon Adsorption and Solvent Extraction": Part I, JAWWA, 65, 1, 57-72 (Jan. 1973); Part II, 65, 3, 195-199 (March 1973).

5. Sylvia, A. E.,"Detection and Measurement of Microorganics in Drinking Water." JNEWWA, 87, 2 (June 1973).

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Acknowledgments

The following Testing Agent staff members participated in the testing program:

Equipment installation, operation and maintenance:

Jim Agee

Ken Kropp

Organic Chemical Analysis

Ron Dressman

Al Stevens

Clois Slocum

Inorganic Chemical Analysis

Brad Smith

Lou Trombly

Ben Moorman

Jim Caldwell

Bacteriological Analysis

Ray Taylor

Virological Anslysis

John Hoff

Judy Barnick

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LABORATORY VERIFICATION TESTING AGREEMENT

PARTIES TO THE AGREEMENT

National Science Foundation
Washington, D.C. 20550

National Environmental
Research Center
Cincinnati, Ohio

Alron Industries, Inc.
Rochester, N.Y.

AGREEMENT NO. CJ-002

PURPOSE OF THE AGREEMENT

To provide verification testing of a technical innnovation by an independent scientifically recognized organization in order to assess the impact of such testing on the future economic development and marketing potential of the innovation.

ESTIMATED COSTS $50,000

Agreement Period

This agreement shall be effective on the date of execution and shall remain in effect until the final report is accepted by the Foundation.

CJ-002

WHEREAS, The National Science Foundation has established a program of Experimental R&D Incentives designed to provide experimental evidence concerning various incentives which the Federal Government might use to increase the application and use of science and technology in the civil sector by (1) identifying institutional barriers to innovation and ((2) testing appropriate Federal action which might reduce such barriers; and

WHEREAS, Alron Industries, Inc. has developed a home water purification system (hereinafter referred to as "the system") to the point where credibility of performance (or lack thereof) will have a critical effect on its further economic development and marketing potential.

WHEREAS, verification testing by an impartial, scientifically recognized testing agent would establish or disestablish that credibility and may thereby influence the economic development and marketing potential of the system.

WHEREAS, The National Environmental Research Center is an impartial, scientifically recognized agent, has the necessary capabilities to undertake verification testing of the system, and has an interest in activities which have the potential of providing enhanced environmental conditions.

NOW THEREFORE, the National Science Foundation (hereinafter referred to as the "Foundation"), the National Environmental Research Center (hereinafter referred to as the "Testing Agent"), and Alron Industries, Inc. (hereinafter referred to as the "Innovator"), do hereby agree to work together as provided hereinafter to achieve the purpose of this agreement.

This agreement consists of the cover page, this page, a signature page, and the attached Special Conditions. Should there be any inconsistency between the Special Conditions and any other provision, which are made a part of this agreement by reference or otherwise, the Special Conditions shall control.

CJ-002

FOR THE FOUNDATION

By Leonard A. Rezucha

LEONARD A. REZUCHA
CONTRACTING OFFICER

Title _____

Date JUN 19 1973

FOR THE TESTING AGENT

By _____

Title _____

Date _____

FOR THE INNOVATOR

By W. Allen Burns

Title President

Date June 13, 1973

This agreement is authorized by and executed under the National Science Foundation Act of 1950, 42 U.S.C. 1861, et. seq., and the Economy Act, 31 U.S.C. 686, et. seq.

Attachment to

LABORATORY VERIFICATION TESTING AGREEMENT

NSF Agreement Number CJ-002

EPA Project Officer: Mr. Gordon G. Robeck
Director, Water Supply Research Laboratory
NERC, Cincinnati
Cincinnati, Ohio 45268

Phone: 513 684-8311

CJ-002

Special Conditions

I. Responsibility of the Parties

A. The Foundation.

1. The Foundation will provide the Testing Agent with the funds necessary to conduct verification testing of the system in accordance with paragraph VII, Payments.

2. The Foundation will provide the Innovator with the results of the verification testing in accordance with paragraph III, Reporting Agreements.

B. The Testing Agent and the Innovator

1. Prior to undertaking any work under this project, the Testing Agent and the Innovator will negotiate Testing Protocol (hereinafter referred to as the protocol) regarding the test program to be undertaken. This protocol will set forth the responsibilities of each party, a schedule and a detailed test program, including all parameters to be tested, conditions under which the tests will be performed, how the data will be recorded, and such other terms and conditions as agreed to. In no event will the testing period exceed one year without the written approval of the Foundation's Contracting Officer.

2. The Testing Agent will conduct the test in accordance with the protocol referred to in B.1. above, except that no work of a developmental or of an evaluative nature shall be performed unless specifically requested by the Foundation and agreed to by the Innovator. The results of the testing will be recorded and reported to the Foundation in accordance with paragraph III, Reporting Agreements.

3. The Innovator will prepare and submit the system for testing in accordance with the protocol negotiated with the Testing Agent and will report to the Foundation on the impact of the test results in accordance with paragraph III, Reporting Agreements.

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II. Schedule and Milestones

A. No later than 90 days after the date of execution of this agreement:

(1) Testing Agent and the Innovator will reach agreement regarding the test program to be undertaken and

(2) The Testing Agent will submit to the Foundation one, fully executed copy of the protocol.

B. In the event the protocol between the Testing Agent and the Innovator is not executed within 90 days, the Testing Agent shall notify the Foundation in writing of the reasons for delay and the prospects for early agreement. The Foundation reserves the right to terminate this agreement if, in its opinion, agreement between the Testing Agent and the Innovator appears unlikely, or if a delay in the execution of the protocol would severely impair the usefulness of this agreement to the Foundation.

III. Reporting Agreements

A. Reporting of Test Results

1. The Testing Agent will record and report the results of the verification testing to the Foundation within 60 days of its completion. This report will include complete records of the results obtained under its testing agreement with the Innovator.

2. The Foundation will provide the results of the testing to the Innovator within 30 days of receipt from the Testing Agent.

3. The Innovator will report to the Foundation on the impact of the testing on the economic development and marketing potential of the system within 3, 6, 9 and 12 months after receipt of the test results and annually thereafter for a period of four years unless this requirement is suspended by mutual agreement. These reports will address such things as ability of the Innovator to attract venture capital and marketing penetration of the system.

B. Dissemination of Test Results

1. The results of the verification testing, as reported to the Foundation by the Testing Agent, shall be public information available on request. The Testing Agent shall refer all requests or inquiries concerning the test results to the Foundation. In no event may such results be used by The Testing Agent or the Innovator other than by transmittal or citation of the full report.

CJ-002

IV. Proprietary Rights of the Innovator

All information concerning or relating to the operation, processes and fabrication of the system, supplied to the Testing Agent or the Foundation and which the Innovator considers proprietary, shall be appropriately marked on each page or drawing with a legend indicating that it is proprietary and shall not be used by the Government for purposes other than testing under this agreement and shall not be provided to persons outside the Government without the written consent of the Innovator.

V. Liabilities and Losses

The Foundation assumes no liability with respect to accidents, bodily injury, illness, breach of contract or any other damages or loss, or with respect to any claims arising out of any activities undertaken under this Agreement, whether with respect to persons or property of the Testing Agent, the Innovator or other parties.

VI. Review and Inspection

The Foundation or its authorized representatives have the right at all times to review, inspect or otherwise evaluate the testing program being performed hereunder and the premises on which they are being performed. The Testing Agent and the Innovator shall provide all reasonable facilities and assistance during such review and inspection which will be carried out in such a manner as to not undaly delay the performance under this agreement.

VII. Payments

The Testing Agent will be reimbursed for services and supplies furnished at actual cost, but not to exceed $50,000. Billings will be submitted to the Foundation's Financial Management Office utilizing Standard Form 1081.

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Test Protocol
for the
Laboratory Verification Test Agreement

Parties to the Agreement

National Science Foundation Washington, D.C.	National Environmental Research Center Cincinnati, Ohio	Alron Industries, Inc. Rochester, N.Y.

Agreement No. CJ-002

A. Definitions

1. "Testing Agent": National Environmental Research Center, Cincinnati, Ohio

2. "Innovator": Alron Industries, Inc. Rochester, N.Y.

3. "Foundation": National Science Foundation Washington, D.C.

B. Responsibilities of each party

1. The Innovator shall furnish at no cost to the Testing Agent the following equipment to the Cincinnati, Ohio site of the verification testing:

(a) 1-Alron Model No. WPCF (4 gpm) Water Purifier with Cartridge Filter Model CF,

(b) 1-Alron Model No. WP (6 gpm) Water Purifier with Automatic Filter Model AF,

(c) 3-Alron Model No. 45 Portable Water Purifiers,

(d) 1-Automatic Filter Model AF (see E.1(h) below),

(e) All additional parts and equipment normally furnished in the installation kit, if any, for these water purifiers.

2. A representative of the Testing Agent shall visit the manufacturing facility of the Innovator for the purpose of receiving instruction in the installation, operation and maintenance of all equipment to be tested.

3. The Testing Agent shall immediately inform the Innovator of any apparent malfunction of any part of the equipment being tested. Under the direction of the Innovator, the Testing Agent will make a reasonable effort to restore malfunctioning equipment to proper operating order. If the Testing Agent is unable to repair the equipment, or believes the extent of the repairs requires more than a reasonable effort, the Innovator shall be responsible for restoring the equipment to proper operating order.

4. Upon completion of the test program, the Testing Agent shall return to the Innovator all equipment, parts, and unused expendable supplies furnished by him.

5. Where possible, analytical methods used by the Testing Agent shall be as described in the 13th Edition (1971) of "Standard Methods for the Examination of Water and Wastewater" APHA-AWWA-WPCF.

6. The Testing Agent assumes no responsibility for verifying all claims made by the Innovator in his advertising literature for the products submitted for verification testing under Agreement No. CJ-002. Only the items agreed to in this Test Protocol will be included in the verification testing.

7. Verificati[illegible]esting, as performed under this Test Protocol, shall not imp[illegible]ner "Approval" or "Endorsement" by the Testing Agent of the eq[illegible]nt tested.

8. The Testing [illegible]ent will perform the verification testing to the limits of time and money described in the Test Agreement No. CJ-002.

C. Test Schedule

1. Verification testing will begin as soon after the approval of this Test Protocol by the Testing Agent and the Innovator as is mutually agreeable to these parties.

2. The equipment to be tested under this agreement, as listed in B.1 above, shall be delivered to the Cincinnati, Ohio testing site specified by the Testing Agent within 30 days after the Innovator is notified to ship the equipment.

3. The Testing Agent will complete the verification testing within six months after the equipment is received and placed in operation at the test site, unless delayed by:

(a) delays in the procurement of equipment and supplies needed to conduct the test

(b) delays in obtaining temporary laboratory technicians to conduct the test, or delays in the negotiation of a sub-contract for the conduct of the test

(c) other unforeseen circumstances.

D. Test Program

1. Basic parameters for which verification of removal efficiency by the equipment is sought:

(a) Iron: Maximum concentration = 30 mg/l

(b) Hydrogen Sulfide: Maximum concentration = 30 mg/l

(c) Manganese: Maximum concentration = 5 mg/l

(d) Organic pollutants: A maximum of 4 compounds will be investigated. Included will be a detergent, a pesticide, and 2 other compounds found in water which are known to cause taste, odor or color problems and/or are toxic to human life. Compounds and their concentrations will be selected by the Testing Agent.

(e) Bacteria: A variety of bacteria of importance in the disinfection of drinking water will be tested. A mixed natural bacterial flora will also be tested. Organisms and their concentrations will be selected by the Testing Agent.

(f) Virus: Organisms and their concentrations will be selected by the Testing Agent.

(g) Odor: Odor removal, as measured by Threshold Odor Number, will be determined where appropriate during the testing of other basic parameters. The results reported will be highly subjective.

(h) Color: Color removal analyses will be made where appropriate during the testing of other basic parameters.

2. Other parameters of interest in the testing program

(a) Removal efficiencies of mixtures

(1) Iron and Coliform Bacteria

(2) Hydrogen Sulfide and Coliform Bacteria

(b) Effect of water flow rate on the removal efficiencies of flow-through units: Basic testing will be conducted at rated capacity of unit. Several basic parameters listed above will be spot-checked at lower flow rates.

(c) Effect of pH: Several basic parameters listed above, will be spot-checked at pH's approximately 1-1/2 units above and below the pH of the test medium.

(d) Water temperature at the inlet and outlet of the water purifier (where applicable)

(e) Water pressure at the inlet and outlet of the water purifier (where applicable)

(f) Water flow rate through the water purifier (where applicable)

(g) Temperature and relative humidity of the air in the immediate vicinity of the water purifier

(h) Dissolved ozone concentration in the water leaving the water purifier (if any).

(i) Ozone concentration in the air in the immediate vicinity of the water purifier (if any).

E. Test Procedures

1. Alron Model No. WP (6 gpm) Water Purifier with Automatic Filter Model AF

(a) Test media for this unit will be Cincinnati tap water which will be passed through the Alron Model No. WPCF (4 gpm) Water Purifier with Cartridge Filter Model CF for the purpose of satisfying any ozone demand.

(b) One hundred gallon batches of the test media will be spiked with various concentrations of the pollutants up to the suggested maximum noted in D.1. above. The initial concentration of the spiked mixture shall be verified by analytical procedures.

(c) The spiked mixture will be pumped through the unit at the maximum flow rate (6 gpm).

(d) After steady state operating conditions are obtained (10 to 15 minutes), a sample or samples shall be collected for analysis of the concentration of the pollutant in the treated water.

(e) Emphasis will be placed in the test procedure on determining the maximum concentration of a particular pollutant that can be removed with 100% efficiency by the unit.

(f) Testing of the mixtures noted in D.2(a) (1) and (2) above will be conducted after the maximum concentrations noted in E.1. (e) above have been determined. Emphasis in the mixture testing will be to determine what maximum concentrations of one component of the mixture can still be 100% removed while keeping the other component of the mixture at the concentration determined for it in E.1 (e) above.

(g) Testing and observation of the other parameters noted in D.2. will proceed as noted and/or deemed necessary by the Testing Agent.

(b) Special tests for Model No. WP

(1) During the bacteriological testing noted in D.1 (e) above, several samples will be collected from a sampling tap installed between the Model No. WP and the Automatic Filter Model AF. The purpose of these samples will be to show the effect on bacterial removal efficiency of the additional ozone contact time provided by the Automatic Filter.

(2) One test run will be made using a raw surface water from the Cincinnati area as the test media. Parameters to be measured will include: bacterial disinfection and odor and color removal. For this test, an additional Automatic Filter Model AF will be installed ahead of the Model WP to provide pre-filtration of the raw surface water.

2. Alron Model No. WPCF (4 gpm) Water Purifier with Cartridge Filter Model CF

(a) Testing of this unit will be to establish whether or not it is "equivalent" to the 6 gpm unit in its ability to remove pollutants selected in D.1. and D.2. above. As such, it will not be tested until the completion of the testing of the 6 gpm unit.

(b) Only sufficient tests will be performed on this unit to satisfy, in the opinion of the Testing Agent, the requirements of E.2.(a) above.

(c) Test media for this unit will be Cincinnati tap water which will be passed through the Alron Model WP (6 gpm) Water Purifier with Automatic Filter Model AF for the purpose of satisfying any ozone demand.

(d) The test media will be spiked and tested as noted in E.1.(b) through (g) above, except that the maximum flow rate through the unit will be 4 gpm.

3. Alron Model No. 45 Portable Water Purifier

(a) Test media for this unit will be distilled water

(b) Four gallon batches of the test media will be spiked with various concentrations of the pollutants up to the suggested maximums noted in D.1. above. The initial concentration of the spiked mixture shall be verified by analytical procedures.

(c) Using the timer control, the unit will be operated for different time periods (up to a maximum of 45 minutes) to determine what treatment time is necessary to 100% remove a given concentration of pollutant. A fresh 4 gal. batch of the spiked test media (at the same pollutant concentration) will be used for each time period tested. Information will also be obtained on the maximum concentration of a given pollutant that can be removed at the 45 minutes maximum treatment period.

(d) Testing of the mixtures noted in D.2.(a) (1) and (2) above will be conducted after the maximum concentrations noted in E.3(c) above have been determined. Emphasis in the mixture testing will be as noted in E.1.(f).

(e) Testing and observation of the other parameters noted in C.2. will proceed as noted and/or deemed necessary by the Testing Agent.

F. Recording of Data

1. All analytical data, observations, notes, descriptions, and other material pertinent to the verification testing program will be entered in a bound 8"x10-1/2" laboratory notebook.
2. This notebook will be sent to the Foundation along with the verification testing report as required by the Contract.

FOR THE INNOVATOR

By A. Alan Brooks

Title President

Date Sept. 10, 1973

FOR THE TESTING AGENT

By J. Keith Caldwell

Title Research Sanitary Engineer, Project Director

Date September 7, 1973

APPENDIX C

SPECIFICATIONS: ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

ALSOP

PRICE LIST AND SPECIFICATIONS FOR INSTALLED WATER PURIFICATION EQUIPMENT

MODEL NO.	DESCRIPTION	PRICE
WP	WATER PURIFIER for up to 6 gallons per minute water flow continuous up to a total of 10 psi iron pipe sulfur. Requires auxiliary filter mount UF to be connected on water problem. 115 Volts AC, 500 Watts capacity. 3 Watts not operating. Dimensions 19½" x 21" x 65" high. Weight 160 lbs.	$1,295
WPCF	WATER PURIFIER for up to 6 gallons per minute water flow continuous up to a total of 10 psi iron pipe sulfur. Includes built in carbonite filter. 115 Volts AC, 500 Watts operating, 3 Watts not operating. Dimensions 19½" x 21" x 65" high. Weight 160 lbs.	1,295

SPECIFICATIONS FOR EACH WATER PURIFIER MODELS WP AND WPCF

Operates automatically only when water is drawn. 20 gallon fiber glass tank rated at 125 for operating and 300 PSI burst. Pressure safety relief valve. Includes operating procedure for purifier 60 to operating temperature range 35° to 120°F, and readings hourly to . Time delay for 5 minute minimum operating cycle. Pilot lights indicate power on, operation and refrigeration. Electric valve prevents unpurified water from entering system except when purifying. Permanent catalyst cartridge converts carbon dioxide back to oxygen. To install, connect inlet and outlet, and plug into electric receptacle.

CF	CARTRIDGE FILTER for up to 6 gallons per minute. Includes a valve, cartridge and fitting to connect to by-pass valve. Cartridge only (minimum order 6) each.	40
AF	AUTOMATIC BACKWASH FILTER for up to 6 gallons per minute. Fiber glass tank. Automatic timer controls number of times per week filter cleans itself. (Drain must be available for backwash water.)	299
IK	INSTALLATION KIT for installation of a water purifier, automatic filter or water softener. Includes by-pass valve with compression fittings, and plastic tubing and fittings. (Specify pipe type and size.)	30
IK-1	Extra plastic tubing and fittings for an additional unit in series.	10

Rev. 2/21/73

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APPENDIX D

TEST LOG - ALRON MODEL WP WATER PURIFIER WITH MODEL AF AUTOMATIC BACKWASH FILTER

Date	Remarks
10/24/73	Receive 4 gpm unit, 6 gpm unit and 2 sand filters from Innovator
10/25/73	Unpack equipment and list shipping damage to 6 gpm unit
10/30/73	Receive repair parts for 6 gpm unit
11/1/73	Install repair parts and begin installation of 6 gpm unit
11/20/73	Received and installed pump for 6 gpm unit
11/21/73	Completed 6 gpm installation (except rotameter). Ran for 1st time. Corrected leaks.
11/27/73	Cincinnati Tap Water - Trace Elements and Wet Chemistry
11/28/73	Cincinnati Tap Water - Trace Elements and Wet Chemistry
11/29/73	Elevated pH - Cincinnati Tap Water
11/30/73	Depressed pH - Cincinnati Tap Water
12/6/73	1st run - Dieldrin
12/7/73	2nd run - Dieldrin
12/10/73	3rd run - Dieldrin
12/11/73	1st run - MBAS
12/12/73	2nd run - MBAS
12/13/73	3rd run - MBAS
12/14/73	2 runs - Styrene
12/17/73	2 runs - Styrene and Ethylbenzene
12/18/73	2 runs - Ethylbenzene
12/19/73	2 runs - 1,2 Dichloroethane
12/20/73	2 runs - 1,2 Dichloroethane and Manganese
12/21/73	2 runs - Manganese
1/2/74	Color
1/3/74	Raw Well Water - Glendale, Ohio

Date	Remarks
1/7/74	Receive and install rotameter
1/8/74	Hydrogen Sulfide and Threshold Odor Number
1/10/74	Hydrogen Sulfide and Threshold Odor Number
1/11/74	Threshold Odor Number (Phenol)
1/14/74	Bacteria
1/15/74	Bacteria
1/16/74	Bacteria
1/17/74	Bacteria
1/18/74	Bacteria
1/21/74	Bacteria
1/22/74	Bacteria
1/23/74	Bacteria
1/24/74	Bacteria
1/25/74	Virus
1/28/74	Bacteria
1/29/74	2 runs - Iron and Color
1/30/74	Generator Failure
1/31/74	Bacteria with Hydrogen sulfide
2/1/74	Generator failure and other problems
2/6/74	Received and installed new generators
2/7/74	Raw Ohio River Water
2/8/74	Bacteria
2/11/74	Bacteria with Hydrogen Sulfide
2/12/74	Bacteria with Iron
2/13/74	Bacteria

Date	Remarks
2/14/74	2 runs - Hydrogen Sulfide and Threshold Odor Number
2/15/74	2 runs - Iron and Color
2/20/74	2 runs - Iron and Color
2/21/74	Generator failure
2/22/74	2 runs - Manganese and Color, 2 and 4 gpm
2/25/74	Threshold Odor Number (Phenol), 2 gpm
2/26/74	Threshold Odor Number (Phenol), 4 gpm
2/27/74	Hydrogen sulfide, 2 gpm
2/28/74	Threshold Odor Number (Geosmin)
3/1/74	Carbon-Chloroform Extract
3/4/74	Ozone flowrate
3/5/74	Electrical power consumption check
3/6/74	Ozone output
3/7/74	Ozone output
3/8/74	Carbon-Chloroform Extract
3/26/74	1,2 Dichloroethane, 4 gpm
3/27/74	1,2 Dichloroethane, 2 gpm
3/28/74	1,2 Dichloroethane, 4 gpm
3/29/74	1,2 Dichloroethane, 2 gpm
4/2/74	2 runs - Ozone output
4/3/74	Generator failure
4/4/74	1,2 Dichloroethane, 4 gpm
4/5/74	1,2 Dichloroethane, 2 gpm
4/8/74	Ethylbenzene, 4 gpm
4/9/74	Ethylbenzene, 2 gpm

Date	Remarks
4/10/74	Ethylbenzene, 4 gpm
4/11/74	Ethylbenzene, 2 gpm
4/12/74	Ethylbenzene, 4 gpm
4/15/74	Ethylbenzene, 2 gpm
4/16/74	Dieldrin, 4 gpm
4/17/74	Dieldrin, 2 gpm
4/18/74	MBAS, 4 gpm
4/19/74	MBAS, 2 gpm
4/22/74	MBAS, 4 gpm
4/25/74	MBAS, 2 gpm
4/26/74	MBAS, 4 gpm
4/29/74	MBAS, 2 gpm
5/1/74	Carbon-Chloroform Extract and Total Organic Carbon
5/7/74	Carbon-Chloroform Extract and Total Organic Carbon, 4 gpm
5/13/74	Carbon-Chloroform Extract and Total Organic Carbon, 2 gpm
5/22/74	Styrene - Total Organic Carbon and RFM
5/29/74	Ethylbenzene - Total Organic Carbon and RFM
5/31/74	1,2 Dichloroethane - Total Organic Carbon and RFM

APPENDIX E

SPECIFICATIONS: ALRON MODEL 45 PORTABLE WATER PURIFIER

ALRON

PRICE LIST

ALRON PORTABLE WATER PURIFIER

Specifications: For Model #45	115 Volts AC, 60 Hz, 30 Watts. Purifier weighs 15 lbs., and two 5 gallon plastic tanks 1½ lbs. each. One tank has spigot. Shipping carton and packing weighs 9 lbs. for total shipping weight of 27 lbs. Purifier about 11" high and 11" diameter, and tanks 10" x 10" x 15". Shipping container is 32" x 21" x 11½". Two plastic connecting tubes 3' each. Electric cord is 6' three wire, and 2 wire adaptor is included. Purifier enclosed in tamper proof plastic housing. Excess ozone changed back to oxygen by permanent catalyst. Ready to use as received, requires no installation. Controlled by 15 minute timer. Purifies 2½ to 4 gallons each operation. No chemicals, charcoal or chlorine required.
Colors:	White, avocado, lemon, green.
Warranty:	Written warranty included with each unit. Guaranteed 1 year for defective parts.
Accessories:	5 gallon tank $4.00 Spigot for 5 gallon tank 1.95 Filter 2.50 Add $2 handling charge for orders less than $15.
Price:	$189.50
Payment:	Cash, check, money order or C.O.D.
Shipping:	$3.00 within 100 miles. More than 100 miles $5.00. Free factory pick-up.
12/4/72	If purchased by mail, there is a money back guarantee if unit is returned within 15 days for any reason.

APPENDIX F

TEST LOG - ALRON MODEL 45 PORTABLE WATER PURIFIER

Date	Remarks
10/1/73	Received 3 portable units. Unpack and test run
10/3/73	Trial run with iron - results poor
10/4/73	1st run - organics mixtures
10/5/73	2nd run - organics mixture, 1st unit failure
10/9/73	Prepare for O_3 output tests
10/10/73	1st run - O_3 output
10/11/73	2nd run - O_3 output and flowrate, 2nd and 3rd units determined to be near failure by Innovator
10/18/73	Received 2nd set of 3 portable units - 1 damaged in shipment
10/19/73	O_3 output and flowrate on 2 new units
10/23/73	Attempt dissolved O_3 tests, suspect failure of 2 new units
10/24/73	Confirm failure of 2 new units, Begin testing 3rd new unit
10/26/73	O_3 output and flowrate on 3rd new unit, attempt dissolved O_3 tests - results poor
10/29/73	Repeat dissolved O_3 test - 3rd new unit failure Stop testing portable units
3/7/74	Received 4 portable units. Unpack and test run
3/11/74	Dissolved O_3 tests on 4 new units
3/12/74	O_3 output and flowrate tests on 4 new units
3/13/74	1st run - manganese
3/15/74	2nd run - manganese
3/18/74	1st run - iron and color
3/19/74	2nd run - iron and color
3/20/74	3rd run - iron and color
3/21/74	4th run - iron and color - 1st new unit failure

Date	Remarks
3/22/74	O_3 output and flowrate tests on 3 remaining units - 2nd new unit failure
3/25/74	Attempt O_3 output and flowrate tests on 2 remaining units - 3rd and 4th new unit failures Stop testing portable units